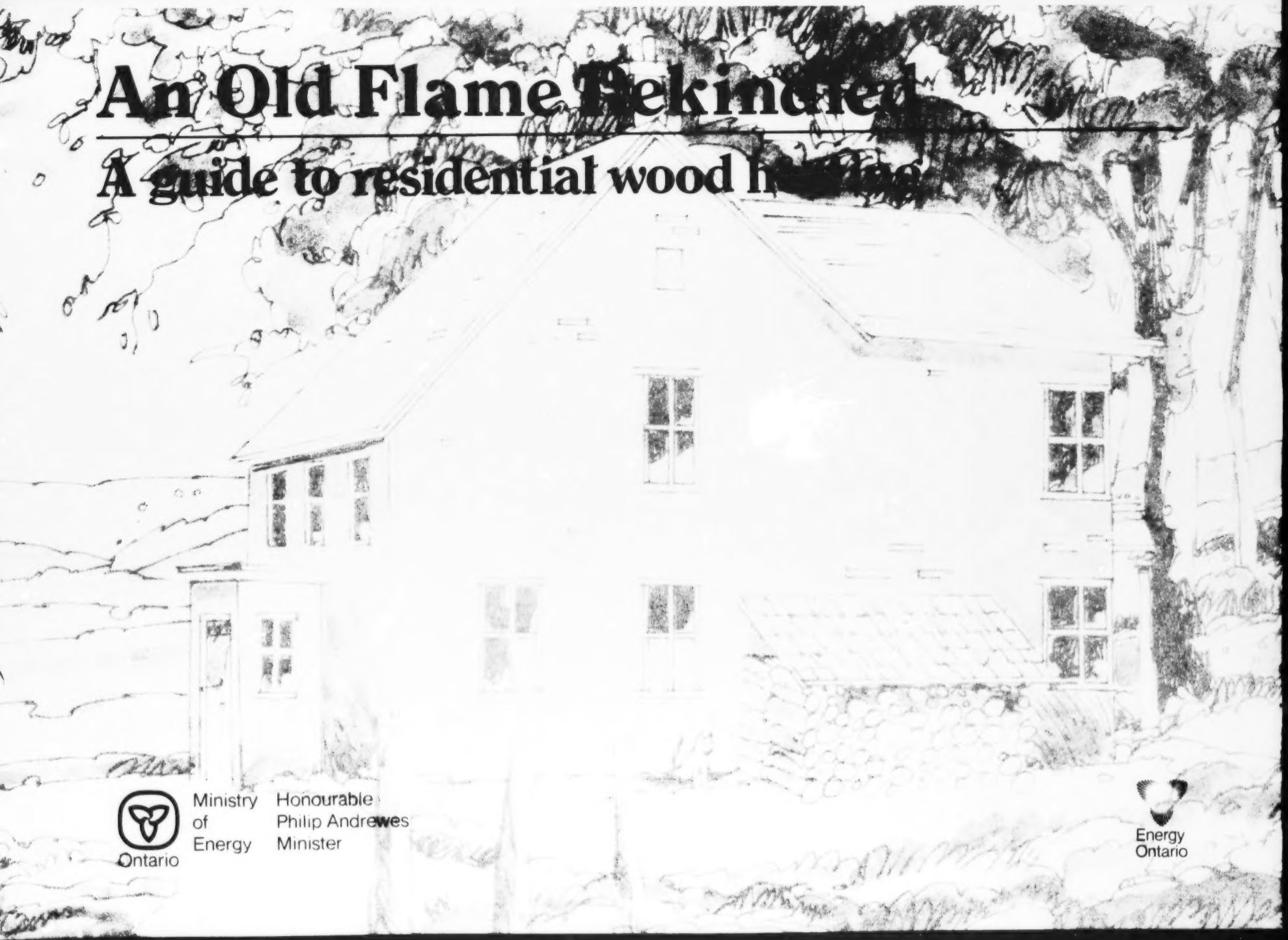
An Old Flame Rekindled

A guide to residential wood h[illegible]



Ministry of Energy
Ontario

Honourable Philip Andrewes
Minister

Energy Ontario

Minister's Foreword

Ontario has a cool, temperate climate. Depending on where you live in the province, you may be required to heat your home for ten or eleven months of the year.

Heating a home today can be expensive. It will undoubtedly be even more expensive in the future.

Fossil fuel resources in Ontario are scarce. The province relies heavily on imports from other Canadian provinces and from foreign countries. To ensure that Ontario residents will continue to enjoy adequate supplies of energy at a reasonable cost in the years to come, the Ontario government has initiated a program* to encourage the expanded use of energy resources that are native to the province.

Ontario's forests are one of the province's greatest sources of natural wealth. The use of wood for home heating holds a great deal of promise for the future. It can help reduce our dependence on imported fossil fuels and, as a renewable resource, it can continue to supply us with energy for as long as trees grow.

This booklet has been prepared by the Ministry of Energy for the cost-conscious homeowner who is considering alternative fuels for home heating. It is also a guide for those who want to get the most from their wood-heating dollar. In the following pages, you will find basic information on the cost of wood-heating equipment, and on the installation and safe operation of the various wood-heating appliances on the market.

Although this booklet has been written primarily for the "serious" wood heat user, anyone now using wood, or who plans to in the future, will find it useful.

Philip Andrewes
Minister of Energy

*Ref. 1

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Chapter 1: An Old Flame Rekindled

Throughout most of human history, wood fire has been the only source of light and heat at our command. In many parts of the world today, most people still use wood for heating and cooking. It is only in the industrialized nations of the world, and only in very recent times, that fossil fuels and electricity have largely replaced wood as a fuel.

Most of us don't realize it, but just 100 years ago, wood supplied more than 80 per cent of the heat for Ontario homes. In those days heating with wood was time-consuming, tedious, inefficient and often dangerous. It is no wonder that, by the early 1950's, most Canadians had switched to the convenient and relatively cheap fossil fuels.

The days of heating with wood are far from over. As the cost of fossil fuels increases, many homeowners are looking for a better alternative. More and more are finding an answer in wood, which currently provides primary or supplementary heat to more than 800,000 Ontario homes[1].

The gap between the cost of fuelwood and the cost of conventional fuels (particularly oil, but to a lesser extent gas and electricity) is expected to widen in the coming years. Although fuelwood is subject to general inflationary pressures, it is a renewable resource. Therefore, if forest resources are properly managed, the price of wood need not be affected by an ever-dwindling supply. As a renewable resource, fuelwood can last virtually forever.

Forest Regions of Ontario

Canada has one of the largest tracts of forest in the world. Perhaps because of this, many Canadians take trees for granted.

Three of Canada's nine forest regions are represented in Ontario – the *Deciduous Forest Region* which is essentially a hardwood forest; the *Great Lakes – St. Lawrence Region*, which consists of a mixture of hardwoods and softwoods, and the *Boreal Forest* which is primarily a softwood, coniferous region (Figure 1).

Hardwoods in general, and a few species in particular – red and white oak, sugar maple, white elm, beech and white ash – are the best Canadian fuelwoods, primarily due to their high density. The heat values of various types of wood are described in more detail in Chapter 4.

Available Forest Biomass

Anyone thinking about switching to wood as a fuel will naturally want to know something about its availability in Ontario, both now and in the future.

Forest biomass for wood energy is available from six separate and distinct sources in Ontario:

Mill residues (sawdust, shavings, bark, slabs and edgings);
Logging residues (including tops of trees and branches);
Salvage of dead or dying timber (trees killed by fire, insects, disease and flood);
Trees not suitable for traditional forest products (i.e. unmerchantable trees from stand improvement and conversion);
Wood from thinnings (trees that are cut down in stand improvement operations primarily from southern Ontario plantation operation);
Forest biomass intentionally produced for energy (plantations of fast-growing hybrid trees).

At present, there is an ample supply of fuelwood for current demands[2]. Several sources have yet to be exploited.

The key to ensuring a supply of abundant and relatively cheap fuelwood for the future is to treat forest resources as *renewable*. One exciting prospect for the future is the promising experimental work currently being done in Ontario with fast-growing hybrid poplar trees on tree plantations.

1. Ref. 2.
2. Ref. 2, 3.

Figure 1: Forest Regions of Ontario

Hudson Bay
James Bay
Lake Superior
Lake Huron
Lake Ontario
Lake Erie
Principal Tree Species
Boreal Forest:
White Spruce, Black Spruce, Tamarack, Jack Pine, White Birch, Trembling Aspen.
Great Lakes – St. Lawrence Forest:
Eastern White Pine, Red Pine, Eastern Hemlock, Yellow Birch, Sugar Maple, Red Maple, Red Oak, Basswood and White Elm.
Deciduous Forest
Beech, Maple, Black Walnut, Hickory, Oak.

Woodlot Management

As will be discussed in greater detail in Chapter 4, good fuelwood can be expensive, particularly in the larger urban centres. One way to keep the cost down, to possibly make a profit, and to assure easy access to fuel is to buy and manage your own woodlot.

The Farm Woodlot[3] and *The Woodburner's Manual: Managing the Woodlot for Profit*[4], published by the Ontario Ministry of Natural Resources, are excellent sources of information on woodlot management. They are available through the Ontario Government Bookstore, 880 Bay Street, Toronto, Ontario/(416) 965-2054. References 4, 7 and 22 (see References section) may also be helpful.

3. Ref. 6.
4. Ref. 5.

Chapter 2: Making the Wood Decision

The Cost of Heating with Wood

The total cost of wood heating includes the cost of fuelwood, the cost of the wood-burning equipment and the cost of installation and maintenance. If you are considering wood heat, you should also keep in mind the extra time it takes to split and stack the wood, bring it into the house, feed the fire, take out the ashes and clean stovepipes and chimneys.

Cost of Wood

The cost of fuelwood varies greatly throughout the province. In most rural areas, where sources are easily accessible, the price is comparatively low. In the large urban centres, the cost of a cord of fuelwood is much higher.

If you buy wood from a dealer, you can easily determine the cost per cord. It is much more difficult to calculate the overall cost if you get fuelwood from your own woodlot, or if you cut wood from a government or private woodlot.

If you cut your own wood, it is important to remember that the cost of the equipment and transportation, as well as the extra time required, are all part of the investment. If you have your own woodlot, the cost of the property must be included; and if you cut wood from a public or private lot, stumpage fees are charged.

Once you know how much wood will cost per cord[1], you can estimate your annual fuelwood bill by using the following formula[2] and the information supplied in Table 1.

How to Calculate the Number of Cords of Wood Required to Heat Your House.

$$\text{Required Cords} = \frac{F \times E_F^{*}}{W \times E_W}$$

Where:

- F = Units of present fuel consumed per year (based on fuel bills)
- E_F = Efficiency of conventional heating method used (from Table 1)
- W = Units of present fuel contained in an average cord (from Table 1)
- E_W = Efficiency of wood burning appliance (from Tables 1 and 5).

*This formula does not consider such factors as house design, insulation level, heat circulation, and the installation and operation of the wood-burning appliance. It provides a rough estimate only.

1. *Wood is measured by the cord. A standard or full cord is a pile of wood 1.2 metres (4 feet) high, by 1.2 metres (4 feet) wide, by 2.4 metres (8 feet) long. Its area is equal to 3.6 cubic metres (128 cubic feet): 2.2 cubic metres (80 cubic feet) of which is solid wood, and 1.4 cubic metres (48 cubic feet) of which is air space.*
   Wood is sometimes sold by the face cord (see Glossary), which is normally only one-quarter to one-third of a full cord. Be certain that the price you pay for a face cord is a proper reflection of its size.
2. *Ref. 8.*

First, you can determine how much oil, natural gas or electricity is needed to heat your house by referring to your fuel bill records and by averaging fuel consumption over several seasons.

Next, because each fuel yields a known amount of heat per unit (measured in Joules[3] or BTU's[4]), you can estimate the equivalent amount of wood required to heat your home. For example, as Table 1 shows, 573 litres (126 gallons) of fuel oil is equal to one cord of air-dried hardwood. Your calculation should also take the efficiency[5] of your heating system into account.

Using the preceding formula a consumer who uses 800 gallons of No. 2 fuel oil, has a standard oil furnace and wants to provide virtually all of his heat with wood, needs about 7 cords per year. If wood costs $50 per cord, his annual fuelwood bill would be 7 x $50 = $350.00.

$$\text{Required Cords} = \frac{3637 \text{ litres} \times .65}{573 \text{ litres} \times .60} = 6.88$$

Table 1: Comparative Data for Use in Calculating Wood Requirements

Fuel Currently Used (F)	Units of Present Fuel Contained in a Full Cord (W):	Average Efficiency of Heating Appliance			
		Fossil Fuel Furnace		Wood Burning Appliance	
		Type	Efficiency (E_F)	Type	Efficiency (E_W)
No. 2 Fuel Oil 38.6 million Joules/litre (166,500 BTU/gal.)	573 litres (126 gals.)	Standard Oil Furnace	0.65	—	—
Propane 21.26 million Joules/litre (91,600 BTU/gal.)	1,046 litres (230 gals.)	Propane Burner	0.60	—	—
Natural Gas 37,280 Joules/m^3 (1,000 BTU/ft^3)	594 m^3 (21,000 $ft.^3$)	Standard Natural Gas Furnace	0.60	—	—
Electricity 3.6 million Joules/kWh (3,413 BTU/kWh)	6,153 kWh	Standard Electric Furnace	1.00	—	—
Wood	22.16 x 10^9 Joules (21,000,000 BTU)			Open Fireplace	.10
				Improved Fireplace	.10 to .30
				Non-airtight Stove	.30
				Fireplace Insert	.40
				Furnaces & High-efficiency Stoves	.60

3. *See Glossary.*
4. *See Glossary.*
5. *See Glossary.*

Cost of Equipment

Equipment can cost from a few hundred to a few thousand dollars[6], depending on individual needs and preferences. Will wood be your primary source of heat or an auxiliary source? How large is the area you want to heat? How well is your house insulated? Is the heating system going to be incorporated into a new house, or an existing one? Will a new chimney have to be built? Is there enough space in your house to allow for the necessary clearances from combustible surfaces? Do you need a heat distribution system? All of these questions have be answered before you can estimate the cost of your wood heating system. These items are discussed in detail in the following chapters and the appendices.

Before you choose wood-heating equipment, you must decide if wood is going to be your primary or auxiliary source of heat. As discussed in the next chapter, there are a number of wood heating units to choose from, including wood stoves, wood furnaces and combination furnaces.

The needs of wood-heat users vary greatly. If your present heating system is relatively new and efficient, you might merely wish to supplement it with another, cheaper system. If your system is obsolete, you may wish to install one or more alternative heating systems.

Converting from Oil to Wood Heating

Many people currently using fuel oil are interested in switching to a less expensive alternative. The 1981 oil pricing agreement between the federal and Alberta governments ensures that oil will become more expensive in the coming years if the international price of oil continues to increase[7].

Modifying Your Oil Heating System

Your oil heating system can be modified in many ways to take advantage of the efficiencies of wood heating and other technologies.

The most obvious addition is a wood stove, although you may find that several stoves, located in different parts of the house, do the job better. You can augment the wood stove(s) with electric baseboard heaters.

Fireplace inserts are another type of woodburning appliance, and these too can be accompanied by baseboard heaters.

An electric plenum heater (heater coils) installed in your oil furnace air duct makes another good partner to either a wood stove or fireplace insert.

An add-on wood furnace or wood-fired boiler are two other wood-burning appliances worth looking into. Either of these can be used in conjunction with a heat pump;[8] which is an electrically operated device that takes warmth from the outdoor air (even in winter), and brings it indoors for use in heating.

Replacing Your Oil Heating System

If you want to replace an oil furnace, you can choose from several wood heat options compatible with an oil heat distribution system. You can also convert to either natural gas or electric heat. Table 2 lists the wood heat options available.

Maintenance and Operating Costs

Annual maintenance expenses (including chimney cleaning) are about 10 per cent of the capital cost of the installed wood-burning appliance. For a standard airtight wood-burning stove, this amounts to at least $90. Fire insurance and fire safety devices must also be purchased (see discussion in Chapter 6). For the purposes of a rough calculation, use $100.

6. *Ref. 9.*
7. *Under the Canada/Alberta Agreement on Energy Pricing, September 1, 1981, oil in Canada will be sold at 75 per cent of the international price by 1986 (Ref. 10). The Agreement was amended June 30, 1983 to maintain the Canadian oil price for the next 18 months, unless major fluctuations occur in the international price of oil.*
8. *See Glossary.*

Table 2: Wood Heat Options Compatible with Oil Heat Distribution Systems*

Type of Heating System Currently Installed	Wood Heat Options Available	Estimated Installed Cost**
	Manual Feed	
Hot Air System	– Wood stove with electric baseboard heaters	$1500 - $2500
	– Combination wood-oil furnace	$1700 - $2500
	– Wood furnace	$2500 - $3500
Hot Water System	– Wood stove with electric baseboard heaters	$1500 - $2000
	– Wood boiler with electric baseboard heaters	$3500 - $4500
	Self Feed* **	
Hot Air System Hot Water System	– Straight stoker and stoker/preheater furnaces – Stoker/boiler system	$3700 - $8300

* This table applies to houses of "average" size – i.e. houses that would need from 2273 litres (500 gal.) to 4546 litres (1,000 gal.) of No. 2 fuel oil per year for heating purposes.

** Ref. 11, 12. These costs do not include the Canada Oil Substitution Program (COSP) grant.

*** Refer to the discussion of advanced systems on page 18. Advanced systems using hot water for heat distribution (i.e. which use a boiler) are considerably more expensive than those using hot air. The price range quoted reflects this difference.

Canada Oil Substitution Program (COSP)

As part of its policy to encourage Canadians to use less oil, the federal government offers financial assistance, with certain stipulations, to homeowners who go "off oil". Any system (including airtight wood stoves) which reduces oil consumption by 50 per cent or more is eligible. The (taxable) COSP grant pays for half the cost of the alternative heating system up to a maximum of $800.

The program is effective for conversions made on or after October 28, 1980 and will continue until December 1990. Application forms are available from the federal government's Conservation and Renewable Energy Office, 2242 Lakeshore Boulevard West, Toronto/M8V 1A5. Keep the COSP grant program in mind when you are estimating the cost of your wood heating system. For more information, call 1-800-268-2207 (toll free) or (416) 252-5866[9].

The Wood Energy Comparison

How does the cost of heating with wood compare with the cost of heating with oil, natural gas or electricity?

The total cost of conversion to wood heat, including the cost of equipment and installation, may range from several hundred to several thousand dollars. Although a wood stove can be less expensive to buy and install than a conventional heating system[10], the operation and maintenance costs may be higher[11]. Substantial short-term savings are possible only if wood is available at a reasonable price.

Keep in mind though, that because oil, natural gas and electricity costs are changing so rapidly, it is difficult to make accurate long-term cost comparisons. You can, however, make a rough estimate of your potential savings.

9. *Ref. 13.*
10. *Ref. 11.*
11. *The capital costs for central wood heating systems are generally greater than the capital costs for wood stoves.*

Table 3: Cost of Home Heating Fuels

Cost Per Unit	No. 2 Oil	Natural Gas	Electricity	Hardwood	
				Rural	Urban
			3.9¢/kWh	$50/full cord	$250/full cord
Energy Cost Per 1 Billion Joules	$13.15 (33¢/L)	$10.28 (23¢/m³)	$10.83	$3.76	$18.81
Energy Cost Per 1 Million BTU's	$13.86 ($1.50/gal.)	$10.85 ($6.51/Mcf)	$11.43	$3.97	$19.84

Assumptions:
1. Heating appliance efficiency is 65% for oil, 60% for natural gas and 60% for wood furnaces and airtight stoves.
2. No. 2. heating oil yields 38.6 million Joules/litre (166,500 BTU's/gallon).
3. Natural gas yields 37,280 Joules/m³ (1000 BTU's/ft³.).
4. Electricity yields 3.6 million Joules/kWh (3413 BTU/kWh).
5. Fuelwood (hardwood) yields 22.16 billion Joules (21 million BTU's) per full cord of seasoned (20% moisture) wood.
6. Based on 1983 fuel costs.

Cost of Fuel

Table 3, based on 1983 figures, shows that the cost of hardwood varies considerably. A full cord of wood – cut, split, dried and delivered to urban areas by the supplier – can cost as much as $250. At the other end of the spectrum, wood which is cut, split and dried by the consumer can cost less than $50 per cord.

According to Table 3, if wood can be purchased for $50 per cord, it costs less to provide 1.055 billion Joules (1 million BTU's) of heat with hardwood than it does with other home-heating fuels.

A consumer using 3637 litres (800 gallons) of No. 2 oil (the equivalent of 14.013 x 10^{10} Joules or 133 million BTU's per season), who wants to provide all of his heat with wood and who can purchase wood for $50 per cord, could save $1,318 annually – ($13.86 - $3.97) x 133.3.

The break-even cost of wood per cord is compared with the cost of oil, natural gas and electricity in Table 4. When you know the cost of each fuel, including wood, you can easily determine if wood is an economical alternative.

Your stove's efficiency also affects potential savings. When properly operated and maintained, a high quality airtight stove can have an efficiency of 60 per cent.

Table 4: Breakeven Costs of Fuels for Home Heating

Fuel Oil		Natural Gas		Electricity	Fuel Wood
¢/L	$/Gal.	$/m³	$/1000ft³	¢/kWh	$/full cord
22	1.00	0.20	5.6	3.2	117
26	1.20	0.24	6.7	3.8	140
31	1.40	0.28	7.8	4.4	163
35	1.60	0.31	8.9	5.1	187
39	1.80	0.35	10.0	5.7	210
44	2.00	0.39	11.1	6.3	234
48	2.20	0.43	12.2	7.0	257
53	2.40	0.47	13.4	7.6	280

The above figures are based on the following efficiencies: existing oil furnace, 65%; conventional gas furnace, 60%; wood furnaces and airtight stoves, 60%.
Heating value of wood is based on dry hardwood (20% moisture content) at 22.16 billion Joules (21 million BTU's) per full cord.

Will Heating With Wood Save Money?

Wood may be an economical alternative to conventional heat sources if it is available at a reasonable cost, if a COSP grant is obtained to defray capital costs, and if the wood is burned efficiently.

Calculating Estimated Savings

Ontario houses come in all sizes, are exposed to many different climatic conditions and have varying levels of insulation. In addition, the cost of fuelwood varies greatly. Because of these factors, the payback period (the time it takes for wood-heating equipment to pay for itself) will also vary.

If you are currently heating your home with oil and are considering wood heat as a supplement or alternative, you can estimate your potential savings by using the following sample calculation.

If you are currently using either natural gas or electricity, refer to the work sheets in Appendix I.

Using the method of estimating savings and payback period shown here, a homeowner who uses 3637 litres (800 gallons) of No. 2 fuel oil may find it economical to convert to a combination wood-oil furnace if he can buy fuelwood for $50 per cord, delivered. At this price, the estimated payback period is less than four years.

The major considerations in the wood heating decision will be discussed in detail in the following chapters – choosing wood-burning equipment, fuel, installation of equipment, and operation and maintenance. We suggest that you carefully consider these factors before making the wood decision.

Sample Calculation of Estimated Savings
(When using fuelwood to supplement or displace fuel oil)

A	Oil consumed in past year	3637 litres (800 gal.)	G Amount of wood required (Full cords)	6.0
B	Expected price of oil	33¢/litre ($1.50/gal.)	H Expected cost of wood fuel (G x F)	$300
C	Expected annual oil consumption if wood burner is installed	454 litres (100 gal.)	I Expected incremental maintenance costs**	$135
D	Expected reduction in oil consumption (A - C)	3182 litres (700 gal.)	J Expected savings due to wood burner (E - H - I)	$615
E	Expected reduction in oil costs (D x B)	$ 1,050	K Expected cost of wood burning installation	$2000
F	Expected price* of good quality hardwood delivered (per cord)	$50	L COSP*** grant	$556
			M Net cost of installation (K - L)	$1444
			N Payback Period (M÷J)	2.3 yrs

* Contact your supplier for the price of a full cord of hardwood in your area.
** Includes incremental cost of furnace and chimney maintenance and fire insurance (Ref. 11).
*** Marginal tax rate assumed to be 30.5%. See discussion of COSP grants on page 6.

Chapter 3: Choosing Wood-Burning Equipment

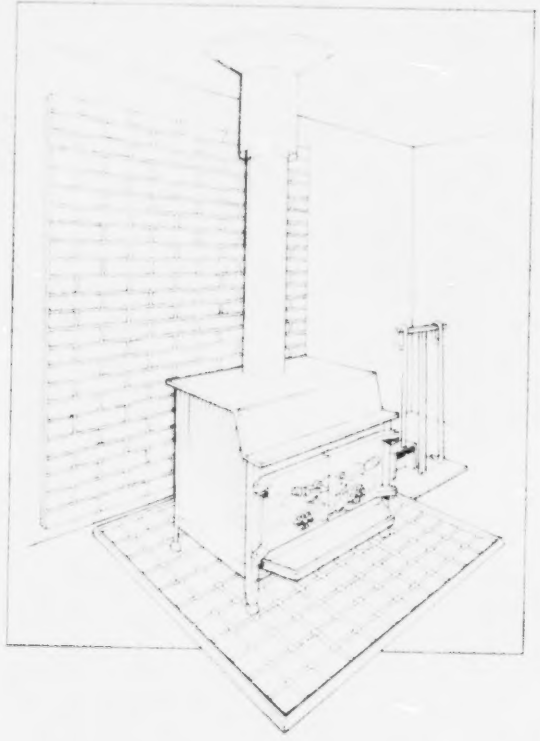
Wood can be used as the primary source of heat for your home, as a supplementary source, or as an incidental, occasional source. Your choice of wood-burning equipment depends to a great extent upon which alternative you select.

Wood Stoves

What is a Wood Stove?

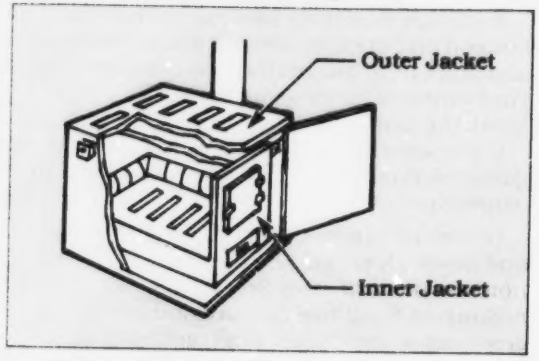
Wood stoves operate on the principle of controlled air combustion. They are available in two basic designs: airtight and non-airtight. Because airtight stoves allow control over the amount of air being drawn into the combustion chamber, they are more efficient and the fire burns longer. (Figure 2).

Figure 2: Typical Wood Stove



While most stoves are of the radiant type, circulating stoves are available. (Fig. 3) Air is heated in the space between the inner and outer jackets, and flows into the room through suitable openings. Because the outer surface of the circulating stove remains relatively cool, they are safer for children and the clearance requirements are less. Refer to page 24 in Chapter 5 (Figure 3).

Figure 3: Typical Circulating Stove



Airtight Designs

There are four basic airtight designs: the updraft or direct flow stove; the horizontal baffle or "S-type" stove; the downdraft stove; and the crossdraft stove (Figure 4).

The *crossdraft* design has proven to be the most efficient of the four. The *horizontal baffle* type is almost as effective in its performance rating while the *updraft* design, which lacks an internal baffling system and therefore good airflow control, has the lowest efficiency (Figure 5).

Figure 4: Stove Draft Designs

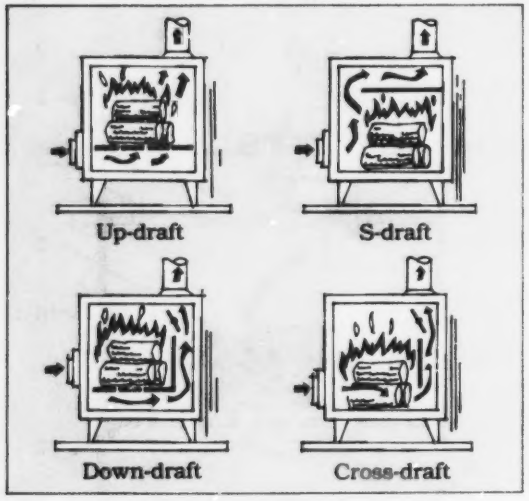
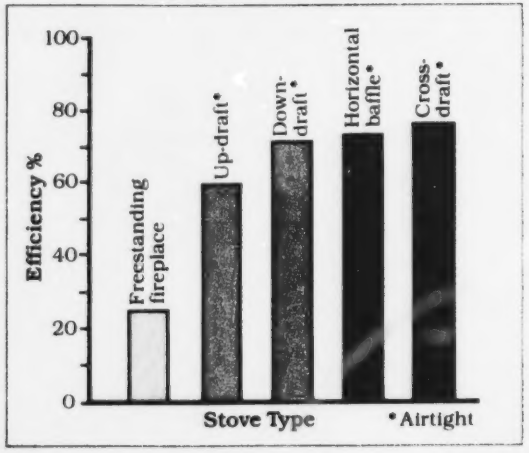


Figure 5: Efficiency of Different Stove Types Under Controlled Conditions



Stove Efficiency

A stove's heating efficiency is based on the percentage of the wood's potential (stored) heat that it can convert to useful heat. Efficiency depends on how completely the stove burns the wood (i.e. *combustion efficiency*), on the *moisture content* of the fuelwood – a certain percentage of the wood's stored energy is used to evaporate moisture in the wood – and on the amount of heat transferred directly into the surrounding room.

The overall efficiency of modern airtight stoves ranges from 40 per cent to 70 per cent (Table 5). Non-airtight stoves have a heating efficiency of about 30 per cent, while conventional masonry fireplaces seldom operate at more then 10 per cent efficiency. Fireplace efficiency is discussed further on page 13.

Table 5: Efficiency Ratings of Wood-Burning Appliances*

Appliance	Efficiency
Masonry fireplace**	–10% to 10%
Factory-built fireplace**	–10% to 10%
Factory-built fireplace with circulation and outside combustion air	10% to 35%
Free-standing fireplace**	–5% to 30%
Fireplace stove	20% to 40%
Airtight radiant stove	40% to 70%
Airtight circulator stove	40% to 55%
Fireplace insert	20% to 45%
Furnaces	40% to 60%

*Ref. 9, 21

**With some of these units, so much warm household air can be drawn up the chimney during and after use that a net heat loss results.

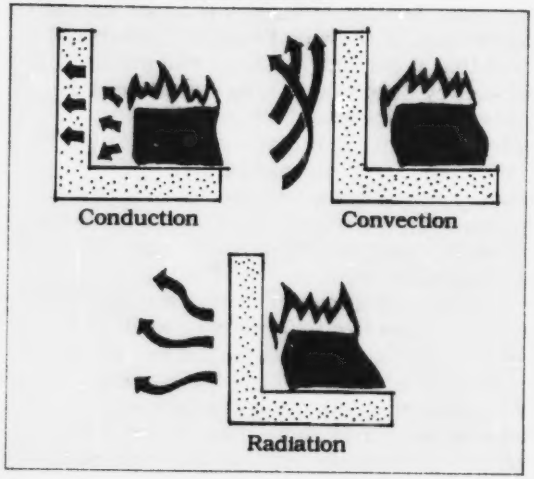
Heat Transfer Efficiency

The heat generated in the combustion chamber of a stove is transferred first by *conduction*[1] to the stove's outer surface and then by *radiation*[2] to the surrounding air. A considerable amount of the heat generated escapes through the chimney. It is therefore important that as much heat as possible is transferred to the surrounding room before this occurs. Heat also circulates through *convection*[3] – warm air tends to rise while cool air sinks (Figure 6). Refer to page 23 for a discussion of heat distribution.

To maximize heat transfer, a stove should be made of a material that is a good heat conductor. Heat transfer surfaces should be large enough to facilitate heat transfer, but not so large as to cause the gases inside the stove to cool to the point of condensation.

Excess air also reduces heat transfer efficiency. If more air enters the combustion chamber than is required, heat loss results when it escapes up the chimney.

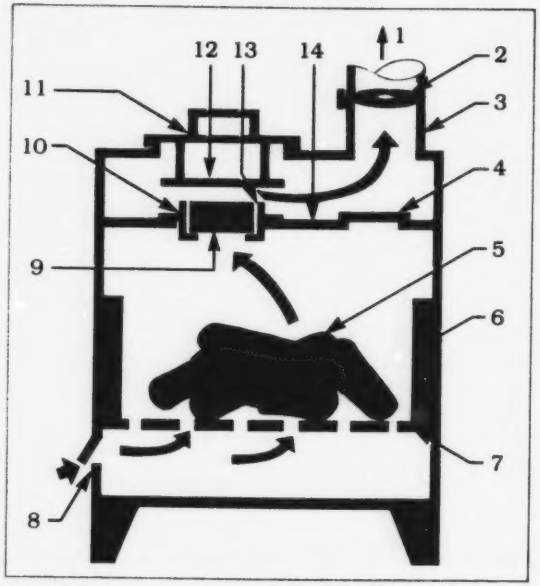
Figure 6: How a Stove Heats



Catalytic Combustors

Catalytic combustors, which increase efficiency, have recently been developed for wood stoves. When used in specially designed stoves, catalytic combustors reduce the ignition temperature of exhaust smoke. Most of the volatile substances in the smoke are burned, resulting in greater extraction of heat, and in minimum creosote formation. To function properly, the combustor must be operated and maintained according to the manufacturer's instructions (Figure 7).

Figure 7: Wood Stove Combustor



1	Chimney	9	Catalytic Combustor
2	Flue Damper	10	Stainless Steel Container
3	Flue	11	Cover W/Handle
4	Bypass Damper	12	Stainless Steel Radiation Shield
5	Wood	13	Thermal Insulation
6	Fire Brick	14	Baffle Plate
7	Grate		
8	Primary Air Supply		

1. *See Glossary.*
2. *See Glossary.*
3. *See Glossary.*

Anatomy and Construction

Figure 8 illustrates the various parts of a typical wood burning stove. Each feature plays an important role in operation and efficiency.

Wood is burned in a *primary combustion chamber or firebox*. Replaceable steel or firebrick liners help the chamber retain heat and save on wear and tear.

The *loading door* should have an airtight seal, be easy to open and wide enough to accommodate the largest logs you plan to use.

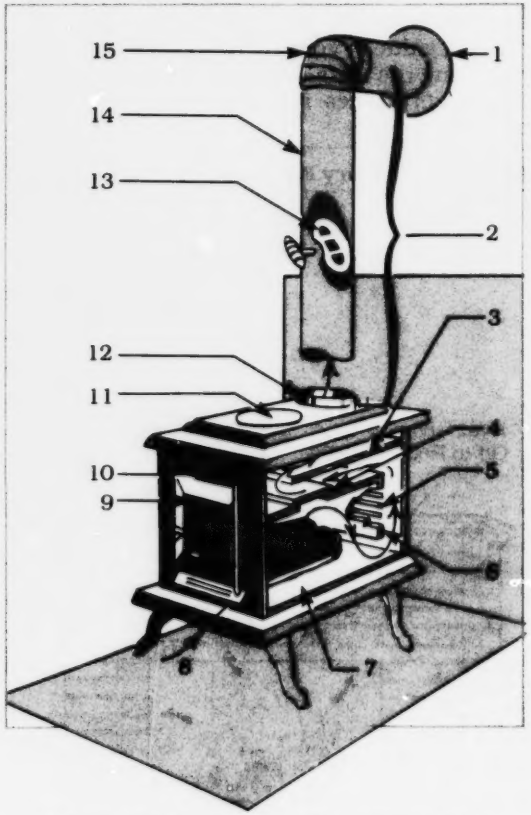
Some airtight stoves with baffles have a *bypass damper* which forces combustion gases to take a longer route through the stove. When lighting the stove, you should open the damper to allow combustion gases to pass directly up the chimney. When the chimney has been warmed, you can close the bypass damper to re-route the gases.

The *secondary combustion chamber* increases efficiency and helps minimize creosote formation. If exhaust gases are above the ignition temperature, combustion occurs in this chamber. The *secondary air inlet* ensures that enough oxygen is present for secondary combustion.

Dampers are used in stoves, fireplaces and furnaces, to regulate the draft. When open, they provide a more direct route for the air to travel and reduce resistance to gas flow (Figure 8).

Most stoves are constructed of cast iron or steel. Cast iron stoves are much heavier because of thicker stove parts.

Figure 8: Anatomy of a Wood Stove



1 Trim Collar
2 Chimney Connection
3 Baffle Plate
4 Bypass Damper
5 Secondary Air Inlet
6 Baffle
7 Firebox
8 Draft Control
9 Airtight Loading Door
10 Automatic Draft Control
11 Pothole Lid
12 Flue Collar
13 Flue Damper
14 Single-wall Stovepipe or Fluepipe
15 Elbow

Heating Capacity

It is difficult to establish the maximum heat output of wood stoves because, unlike conventional fossil fuel and electric heaters, wood stoves do not produce an even, consistent heat. In addition, the stove industry has yet to establish accurate standards for rating the average heat output of available units, although manufacturers often provide a BTU rating[4].

It is extremely important to choose a stove with a suitable heating capacity[7]. If you buy a stove that is too large, it will frequently be underfired, resulting in reduced efficiency and excess creosote formation. An undersized stove, on the other hand, will not produce enough heat unless it is overfired, thus creating a fire hazard. A method for sizing a wood stove is described in Chapter 5.

Buying Your Wood Stove

Airtight stoves range in price from a few hundred dollars to $1,000 or more. It is advisable to buy the best stove you can afford. The extra money spent on a good stove will probably be returned through the greater savings made over a few seasons. However, some lower priced stoves do offer very good value.

4. *The stove industry is in the process of standardizing testing methods to determine heating capacity. Until such standards are developed, you should rely on the experience of stove dealers, installers and users.*
5. *For some situations, it might be best to buy two small stoves or one large and one small stove. If you want to heat more than one room, two stoves might be the best choice. One large and one small stove might be most appropriate for year-round heating. The small one can operate in the fall and spring; the large one during most of the winter and both on the coldest winter days.*
6. *See Glossary.*

Because there are so many stoves available today, see as many as possible before making your final decision. Talk to experienced owners as well as dealers. Appendix II contains a list of some Ontario-based wood-burning equipment manufacturers.

Certification

Wood heating appliances in Canada are certified[7] by three agencies: the Canadian Standards Association (CSA), Underwriters Laboratories of Canada (ULC) and Warnock Hersey Professional Services Limited. Certified appliances are recommended because such factors as design, fabrication, materials and installation instructions are covered. In addition, only certified units qualify for COSP grants (see page 6). Unauthorized modifications void certification.

Fireplaces

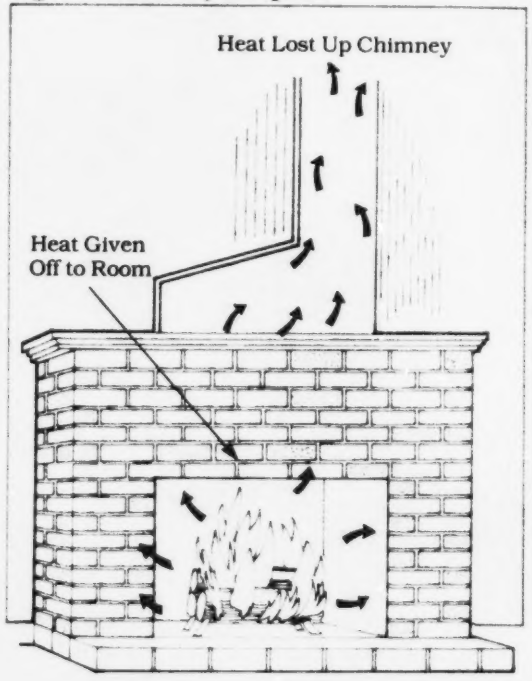
In pioneer days, the fireplace was the centre of family life. It provided the only source of heat during long cold winters and was used for year-round cooking.

Today, fireplaces are more decorative than functional. They are still as inefficient as ever, though. Even the best design rarely exceeds a 10 per cent efficiency rate and the operation of some fireplaces actually results in a net heat loss.

A wood stove or wood-burning furnace is a much better choice than a fireplace if your primary concern is optimum heating efficiency. Fireplace inserts are also reasonably efficient heaters.

If you enjoy the simple pleasure of relaxing in front of a crackling, open fire, do not despair. There are ways to increase the heating value of your fuelwood dollar, including the installation of two different types of fireplaces: masonry and factory-built.

Figure 9: Masonry Fireplace



The *masonry fireplace* is the traditional type (Figure 9). It adds a dimension of strength, durability and beauty to the interior of a home. Modern units are built according to precise ratios to maximize operational efficiency. Masonry fireplaces, however, do not conduct heat well, nor do they allow the control of combustion air.

Factory-built fireplaces come in a variety of designs. They are portable and can be quickly and easily installed in almost any room. Available in regular and heat-circulator models, they are generally well-designed and are at least as efficient as masonry units. Some have ductwork to help distribute heat throughout the house.

Some of the most efficient factory-built models have a built-in double-walled firebox. Several designs use fresh outside air and feature glass doors and draft control mechanisms. The most efficient heat liner fireplaces have a burning efficiency approaching 50 per cent (Figure 10). The major drawback is that this type of manufactured fireplace is expensive to install in an existing house.

Free-standing convective metal fireplaces can have an efficiency of up to 40 per cent (Figure 11). Layered walls with air spaces between the layers and glass doors help to achieve this high efficiency level.

8. *See Glossary.*

Figure 10: Factory-built Fireplace

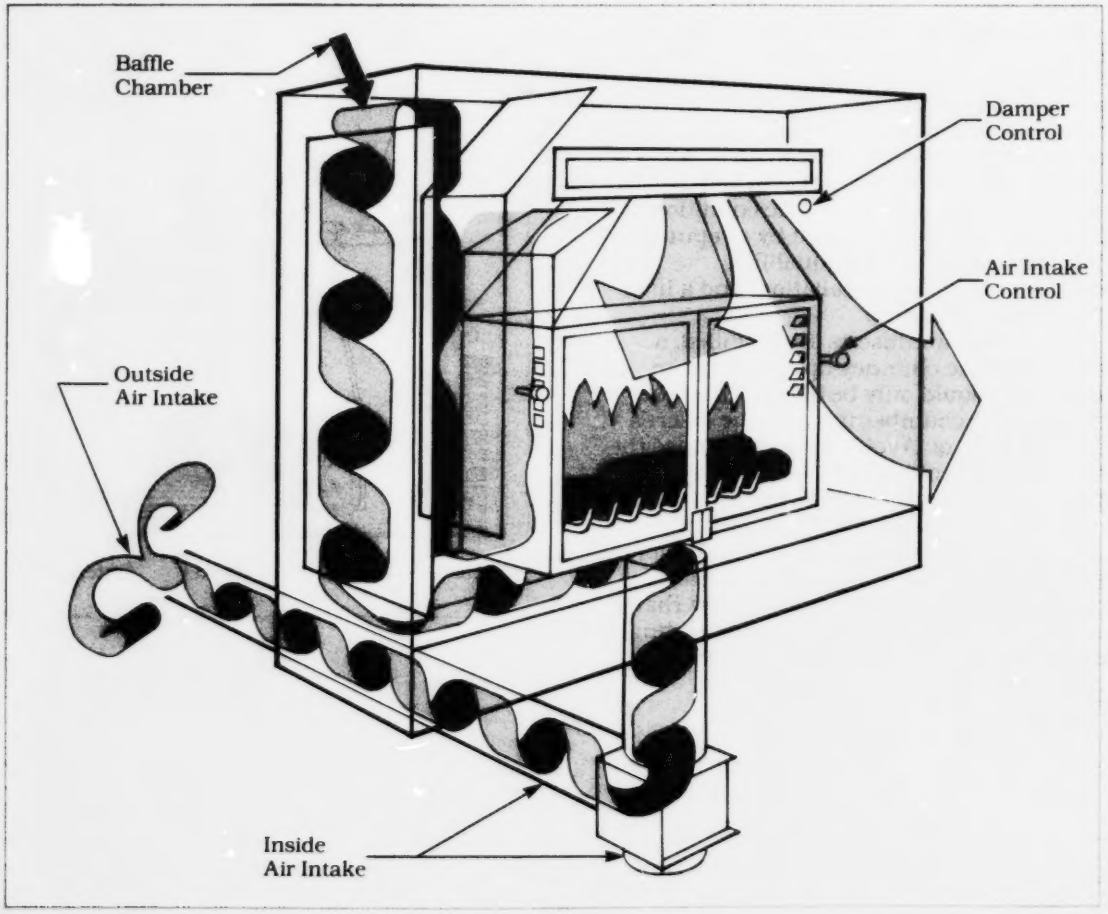
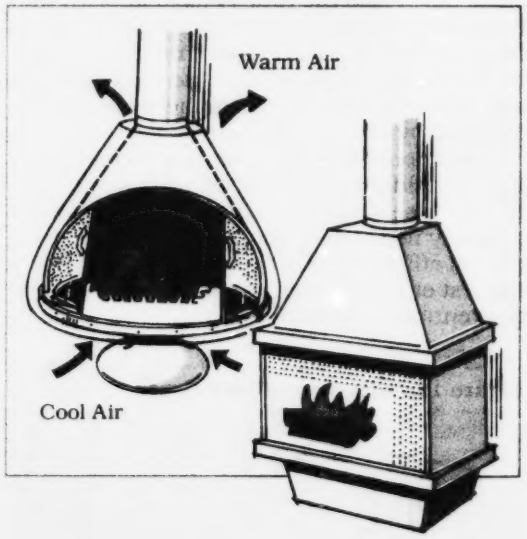


Figure 11: Free Standing Fireplace



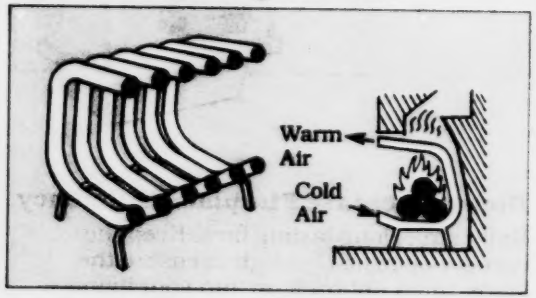
How to Increase Fireplace Efficiency

Build large, long-lasting fires. Keep the damper open just enough to ensure the smoke does not back up into your living area. Close the damper completely when the fireplace is not in use. Cover the fireplace opening with sheet metal or tight-fitting tempered glass doors when the fire begins to wane and when the fireplace is not being used. Build a fire so that it will be out by the time you go to bed. This will prevent warm air from escaping during the night through the open flue.

Tubular grates (Figure 12) help improve efficiency. Place the tube ends flush with the fireplace opening so the hot air emerging from the top of the grates will not be drawn back into the fireplace. *Electric blowers* can also be installed to circulate the warm air expelled by the tubular grates.

Glass doors increase fireplace efficiency, but are seldom airtight because it is difficult to form a seal against rough masonry. When properly used, glass doors can result in an overall efficiency of 10 per cent – about the highest efficiency that can be reached with a conventional fireplace.

Figure 12: Heat-saving Tube Grate



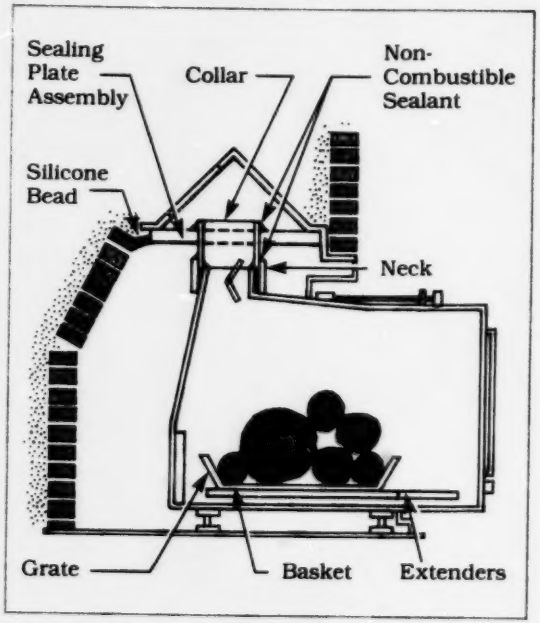
Fireplace Inserts

Inserts are specially-designed appliances that fit tightly into the fireplace, forming an airtight seal with the chimney (Figures 13A and 13B). They can raise the efficiency of a conventional masonry fireplace to about 40 per cent. Because they fit into an existing flue and hearth, they are less expensive to install than a wood stove. The condition of a fireplace should be checked by a reputable chimney sweep or other qualified professional before installation, and a liner installed if necessary.

When fireplace inserts are installed, a plate seals the chimney opening (Figure 13A). Air should only be able to enter the combustion chamber through the insert's air inlet control. Avoid hot fires because the masonry assembly might be raised to a higher temperature than it can withstand.

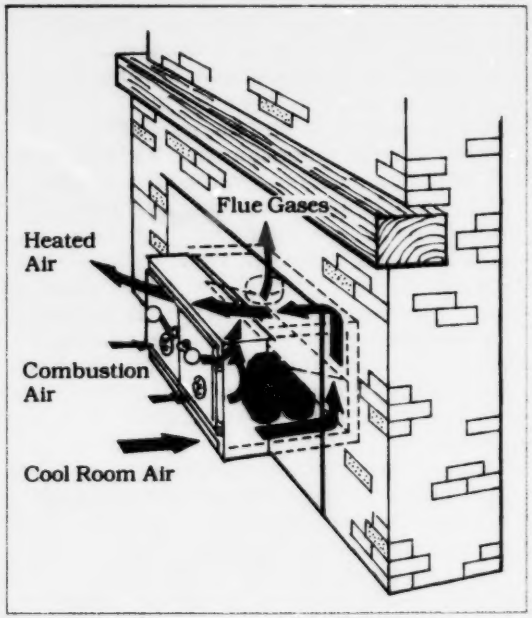
If you use your fireplace regularly, the installation of an insert can save you money, particularly if you live in a large urban centre. Be sure to purchase an insert that is CSA or ULC approved. At time of printing, inserts were not covered by the COSP[8] program.

Figure 13A: Fireplace Insert



8. *Any wood-oil or wood-electric appliance must be approved by the CSA, ULC or Warnock Hersey. Since standards for wood-gas furnaces have yet to be developed, the use of this type of appliance is illegal in Ontario.*

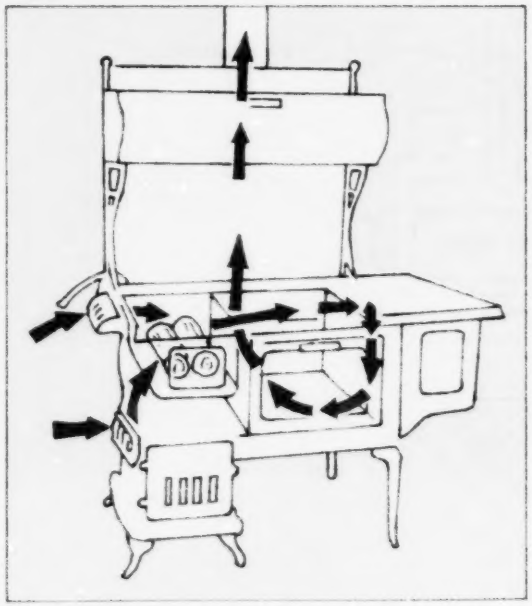
Figure 13B: Fireplace Insert



Cookstoves

Older cookstoves are seldom as efficient as modern airtight models because most are leaky and lack controlled combustion air inlets. Some modern cookstoves are equipped with baffles which re-route unburned combustion gases over the flames or coals (Figure 14).

Figure 14: Cookstove



Wood Furnaces

While a wood stove is a localized heating device, a wood furnace is part of a central heating system. Wood-burning furnaces provide superior heat distribution and circulation, do not take up valuable living space (they are located in the basement), and are cleaner than wood stoves because wood and ashes do not have to be handled in living quarters.

Conventional, Manually-fed Systems

Wood-fired warm air furnaces consist of a firebox (sometimes firebrick-lined) and a baffled heat exchanger. The flue gases leave the firebox (or combustion chamber) and flow through the heat exchanger. Here, air from the house is heated and carried to the living areas through hot air ducts (Figure 15).

Many of the newer, factory-built models feature thermostatically-controlled drafts and electric blowers to circulate the warm air.

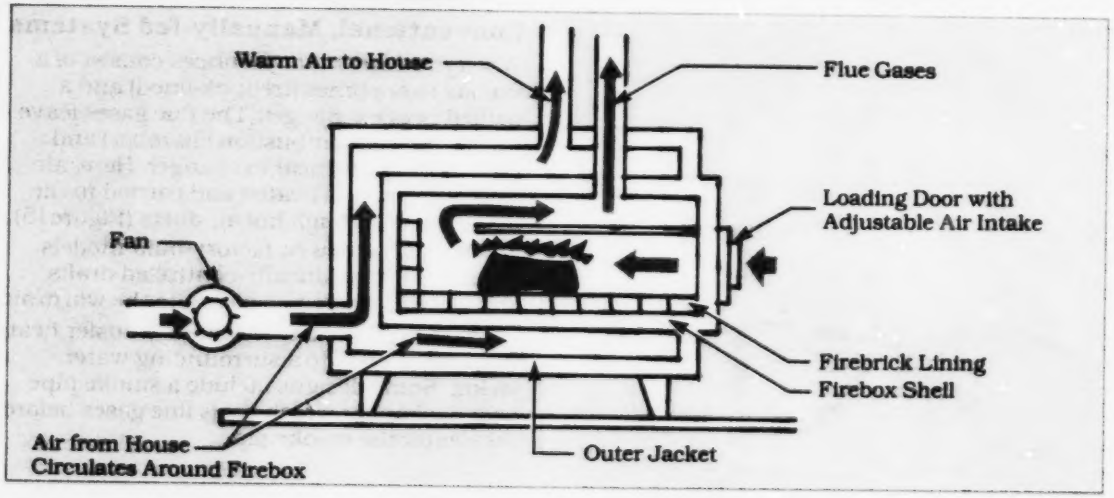
Wood-fired hot water boilers transfer heat from the firebox to a surrounding water jacket. Some designs include a smoke pipe heat exchanger which cools flue gases before they enter the smoke pipe.

When the water temperature in the boiler falls below a pre-set limit (usually 82°C or 180°F), the damper opens to increase the rate of combustion. A house thermostat controls a circulator which pumps heated water through the house distribution system. As a safety feature, excess heat can be expelled into the house, even if the thermostat does not call for additional heat.

A wood-fired furnace with a *water preheat system*, can also supply 60 to 90 per cent of domestic hot water during the heating season.

Wood-burning furnaces have to be refuelled approximately every three hours. You can avoid this inconvenience by using a *combination furnace*.

Figure 15: Wood-fired Warm Air Furnace



Combination Furnaces

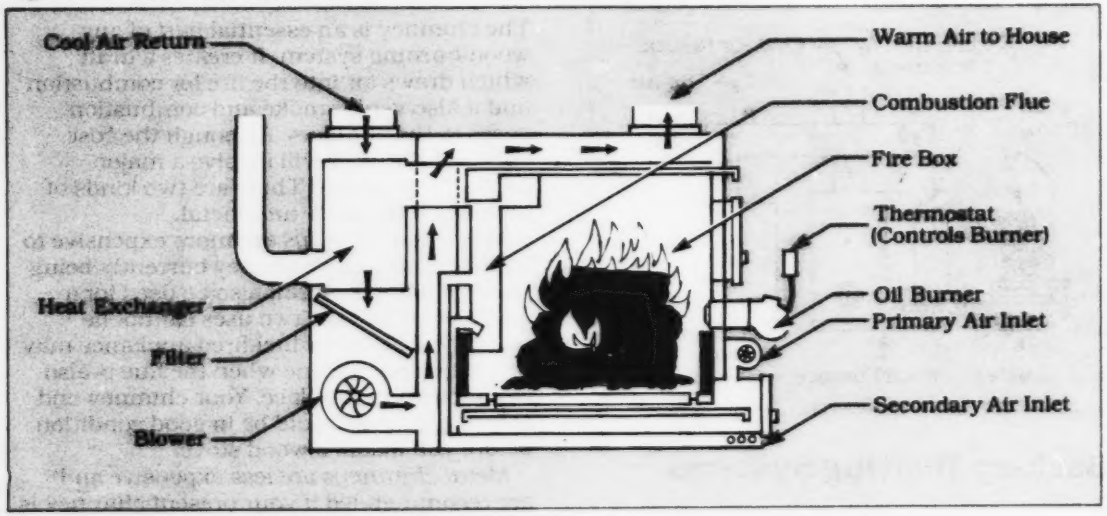
The most common type of combination furnace is the *wood-oil furnace*, although *wood-electric* furnaces and *wood-gas furnaces*[9] are also available. Combination furnaces usually employ a hot air distribution system and have separate combustion chambers for each fuel (Figure 16). Some models, however, have a single combustion chamber. As long as the wood fire is burning to a certain intensity in a combination furnace, the wood carries the heating load, but when the wood fire dies down, the alternate heating system cuts in.

A thermostat in the living area controls the heat distribution system of combination furnaces and the wood fire is partially controlled by an automatic draft mechanism.

Add-on units are wood-burning appliances which are added on to oil or gas furnaces. They must be connected "in-series" and must be certified to the applicable Canadian Safety Standards (CSA-B 366 M). Add-on "in-series" wood-burning furnaces must be connected downstream from the conventional unit. Under no circumstances should the hot air from a wood furnace be blown through the conventional unit.

9. *Any wood-oil or wood-electric appliance must be approved by the CSA, ULC or Warnock Hersey. At present, since there are no standards for wood-gas furnaces, the use of this type of appliance is illegal in Ontario.*

Figure 16: Dual Fuel Furnace



Advanced Self-Feeding Systems

A number of new, convenient, self-feeding wood furnaces are currently in the development stage in Canada. These "stoker" furnaces feature a thermostatically-controlled device which automatically transfers fuelwood from a storage bin into a combustion chamber. They are available in two basic designs: the straight stoker and the stoker/preheater. Both types use either a hot air or a hot water distribution system (Figures 17, 18, 19). These units can burn only wood chips or wood pellets[10].

Straight stoker systems consist of a wood storage bin (or hopper), a stoker mechanism and a combustion chamber. Models using hot water to distribute heat also have a boiler. Stokers burn both wood chips and wood pellets. The drier the wood, the greater the heat output.

The *stoker/preheater* furnace, which is very similar to the straight stoker, uses a preheating device or gasifier. Moist wood chips are burned in the gasifier in a low oxygen atmosphere, producing a hot, volatile gas. The gas then flows into a secondary combustion chamber, igniting when exposed to oxygen-enriched air. Heat radiates from the brick-lined combustion chamber to adjacent cool air or water, which is then circulated throughout the house.

The stoker/preheater has several advantages. Since it is attached to an existing oil-burning furnace, there is no need to invest in a complete new wood-burning furnace. It has its own built-in back-up heating system. The green (unseasoned) wood chips used in the preheater are considerably cheaper than either dry wood chips[11] or processed wood pellets.

Although these advanced designs are widely used in Sweden, they are not yet generally available in Canada.

Test work conducted by the research staff at the Institute of Man and Resources in Charlottetown[12] indicates the capital cost of these advanced systems can be competitive. If access to wood chips or pellets becomes widespread, they could become an economical heating alternative.

10. *Woodlot owners or others who have easy access to a primary wood supply (i.e. those who cut their own wood), can make their own wood chips by using a "chipper". Several individuals in this situation might find it economical to purchase a small chipper on a cooperative basis. See page 21 for a discusssion of wood chips and wood pellets.*
11. *Ref. 12.*
12. *Ref. 11.*

Figure 17: Straight Stoker System

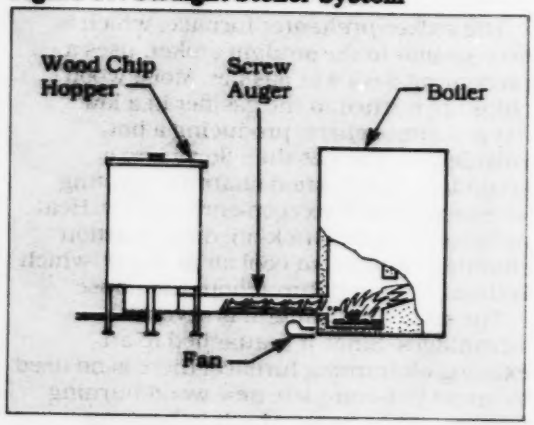


Figure 18: Stoker/Preheater Furnace

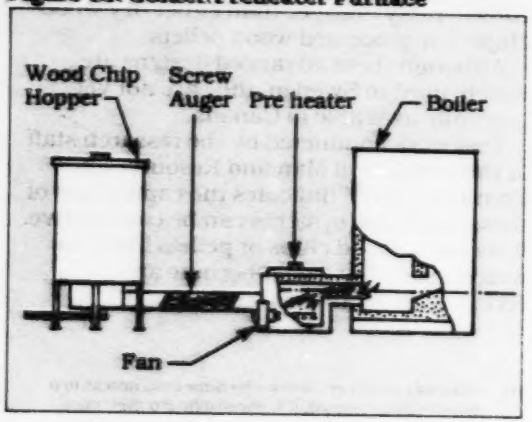
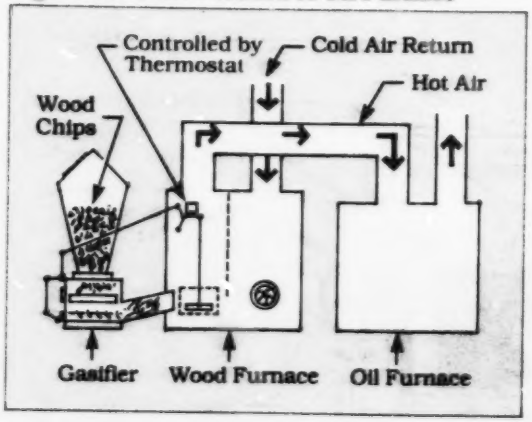


Figure 19: Stoker Added to Oil Furnace



Back-up Heating Systems

You should never leave a house which is heated entirely with wood unattended for more than a day or two when outside temperatures are below the freezing point. If you do, you risk frozen pipes. The problem can be solved by installing either a small electric back-up heating unit (for less than $500) to heat only the pipes, or by using a complete electric heating system (which costs at least $1,000) for back-up heating.

If you decide to convert to wood heat, you will probably be able to use your present oil, gas or electric system for back-up heating. A back-up system can also provide supplementary heat on the coldest days. If you want to reduce oil or gas consumption as much as possible, an electric baseboard system or a small electric furnace are your best back-ups.

Chimneys

The chimney is an essential part of any wood-burning system. It creates a draft which draws air into the fire for combustion and it also vents smoke and combustion gases to the outdoors. Although the cost varies, a chimney will involve a major capital investment. There are two kinds of chimneys: masonry and metal.

Masonry chimneys are more expensive to install. A masonry chimney currently being used for a fireplace can also be used for a wood stove, but the two uses cannot be combined. No other fuel-fired appliance may be connected to a flue when the flue is also connected to a fireplace. Your chimney and chimney lining should be in good condition before you install a wood stove.

Metal chimneys are less expensive and are recommended if your present chimney is not adequate. Never use a metal chimney which has been designed for an oil or gas furnace with a wood-heating system. Instead, install a factory-built chimney (listed by ULC) which is specifically designed for solid fuel burning (Chapter 5).

Make sure your chimney is installed properly and that it meets current building codes. Refer to Chapter 5, page 26, for a discussion of chimney installation.

Chapter 4: Wood As a Fuel

Which Wood Burns Best?

All woods come under one of two categories: hardwood or softwood. Hardwoods include all species of broad-leafed, usually deciduous trees such as oak, hickory and maple; while softwoods include the conifers and other needleleaf evergreens such as pine, fir and cedar.

Characteristics of Hardwoods vs. Softwoods

Hardwoods
denser
high heating value per cord
burn slowly
produce even heat
moderate creosote formation

Softwoods
less dense than hardwoods
lower heating value per cord than hardwoods
high resin content
burn hot and fast
form more creosote (if resinous) than hardwoods

Heating Value

Given the same moisture content, all species of wood have a similar heat content (ie. yield a similar amount of heat per kilogram). However, because hardwoods are more dense than softwoods (they contain more wood per unit of volume), they yield a considerably higher number of Joules (BTU's) per cord.

Table 6 shows the heating value of various tree species native to Ontario. In general, species with higher densities have higher heating values.

The moisture content of wood affects its heating value. "Seasoned"[1] (air-dried) wood yields more net heat than green wood. Refer to Chapter 6 for a discussion of creosote and safety.

Table 6: Heating Values of Tree Species Native to Ontario*

Species	Available Heat per Full Cord	
	Joules (billion)	BTU's (million)
The Hickories	25 - 27	24 - 26
The Oaks	22 - 24	21 - 23
Beech	23	22
The Birches	20 - 23	19 - 22
Sugar Maple	23	22
The Elms	18 - 22	17 - 21
Other Maples	15 - 20	14 - 19
Tamarack	19	18
The Pines	13 - 19	12 - 18
Balsam Fir	18	17
The Cedars	12 - 17	11 - 16
Basswood	15	14
The Spruces	15	14
The Aspens	14	13

Source: CWEI (Ref. 14).

* The above values are for seasoned wood (20% moisture content). Much of Ontario is covered with hardwoods such as maple, beech, oak and birch. In Northern Ontario, however, the only hardwoods in plentiful supply are white birch and poplar.

1. *See Glossary.*

Where Do You Get Fuelwood?

Fuelwood is available from three primary sources: dealers, private woodlots and public woodlots (Crown land). If you use private or government woodlots, you usually have to cut your own wood. In general, the more effort you expend and the shorter the distance between the wood source and your home, the less you will have to pay per cord. A cord of wood is also known as a standard or bush cord (Figure 20).

Approximately 90 per cent of Ontario's forest land is Crown-owned and is administered by the Ontario Ministry of Natural Resources. Fuelwood permits are issued by the ministry.

Preparing and Storing Wood

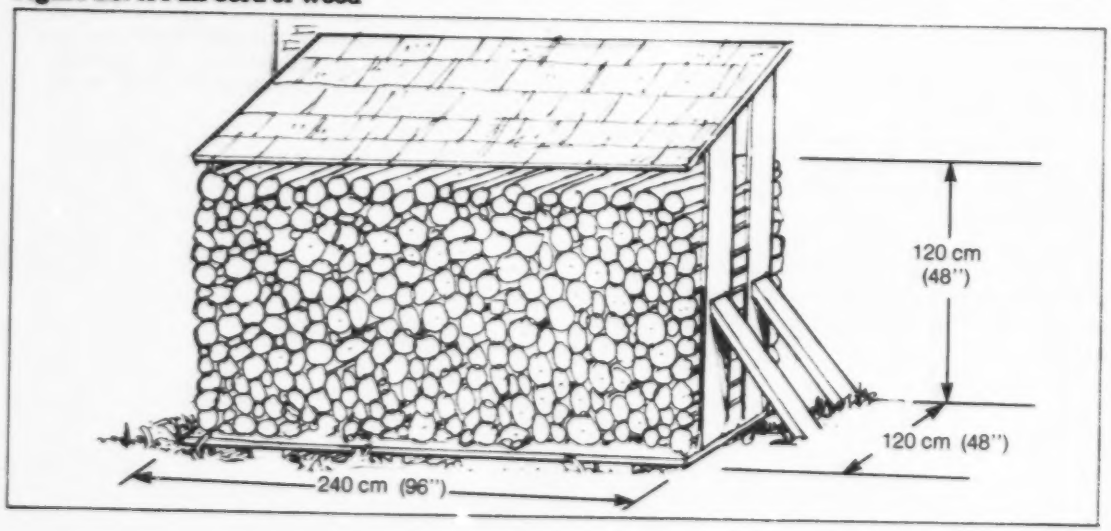
A cord of hardwood may lose up to 1500 pounds of water in the drying or seasoning process. Green wood can have a moisture content of up to 60 per cent, while seasoned wood is about 20 per cent water.

If you cut wood one fall and winter, and store it properly, it should be dry enough to burn the following winter. The best drying times are spring and summer.

Before stacking wood for seasoning, cut it into lengths which fit your appliance's firebox. Then split the wood to facilitate drying and promote burning.

Store wood off the ground in a shelter allowing maximum air flow around the individual pieces[2]. The best place for a shelter is in a dry windy spot, exposed to the sun.

Figure 20: A Full Cord of Wood



Wood Chips and Wood Pellets

Wood chips, used in self-feeding wood furnaces, are usually produced from mill wastes or logging residues. They have a moisture content of 20 to 50 per cent and are easier and cheaper to produce than wood pellets.

At present, production of wood chips is limited because of a lack of demand. However, production is expected to grow, and the price to become more attractive when self-feeding stoker furnaces become widely available.

Wood pellets are made from compressed wood. The pressurizing process draws out over 90 per cent of the moisture and tightly binds the cellulose fibre of each pellet. Wood pellets are recommended for straight stoker wood furnaces.

Pellets can be more conveniently transported and stored than wood chips because they take up less space. BioShell[3] is currently operating two wood pellet plants in Ontario, and is selling pellets to local forestry industries. A packaging and distribution system, intended to make pellets available to the residential market, is currently under development.

2. *Ref. 15.*
3. *BioShell Inc., Suite 204, 6070 Sherbrooke Street East, Montreal, Quebec, H1N 1C1.*

Chapter 5: Installing the Wood-Heating System

Sizing Your Wood-heating Appliance

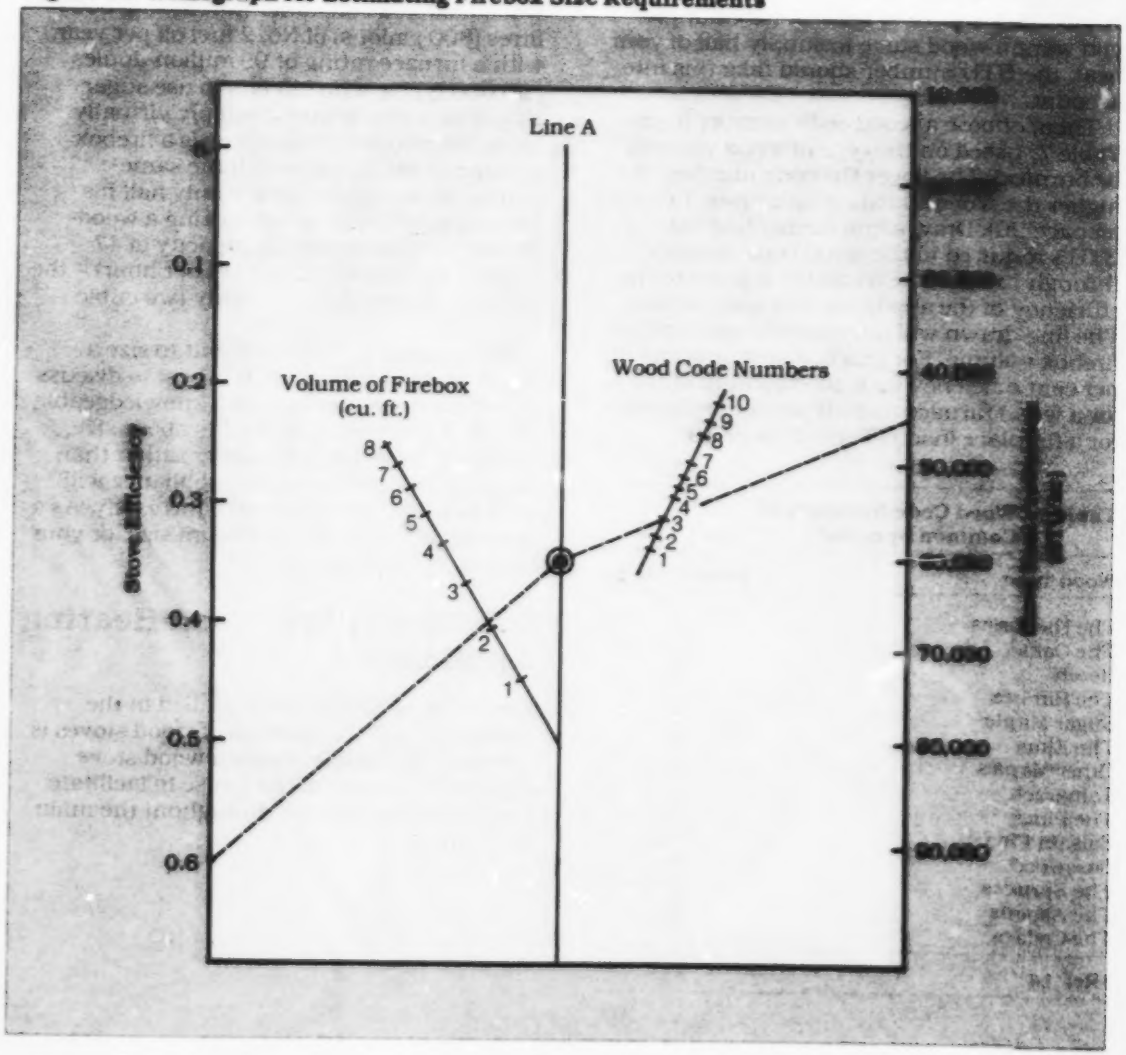
It is often difficult to determine the proper size for a wood-heating appliance. The BTU, cubic foot and square foot ratings commonly given to stoves and furnaces by the manufacturers, are no more than estimates. The size of the appliance's firebox, the heating value of the fuelwood burned (Table 6), how the appliance is operated (i.e. the intensity of the fire), and the characteristics of the house (ie. insulation level, air tightness, number and size of doors and windows etc.) all affect a wood heater's performance.

Manufacturers' ratings can, however, give you a rough idea of an appliance's capacity.

The firebox volume of a wood-heating appliance is generally a reliable yardstick for estimating its heating capacity. A larger firebox will increase the rate (BTU's per hour) at which a wood stove or furnace releases heat and/or the length of time during which a useful amount of heat is released (burn time).

The accompanying nomograph (Figure 21), plus Table 7, can help you estimate the size of the firebox you need. Starting at the right side of the graph, choose how many BTU's per hour your wood appliance should be capable of producing. You can base this estimate on the capacity of your present furnace (all furnaces have BTU ratings); or on the assumption that an average home in Ontario requires from 79 million to 106 million Joules (75,000 to 100,000 BTU's per hour) in very cold weather, to maintain a comfortable interior temperature of 20°C (68°F).

Figure 21: Nomograph for Estimating Firebox Size Requirements



Next, decide if wood will be your primary or auxiliary source of heat. If, for example, you want a wood stove to supply half of your heat, the BTU number should take this into account.

Then, choose a wood code number from Table 7, based on the type of wood you will be burning. The lower the code number, the higher the wood's heating value (see Table 6 on page 20). Draw a line connecting the BTU's required to the wood code number, through to Line A. Connect this point to the efficiency of the appliance you want to buy. The line drawn will intersect the appropriate firebox volume. For this last step, assume 60 per cent efficiency for a good airtight stove or for a wood furnace and 40 per cent efficiency for a fireplace insert (Table 5, page 10).

Table 7: Wood Code Numbers of Common Species*

Wood Type	Wood Code No.
The Hickories	1
The Oaks	3
Beech	3
The Birches	3
Sugar Maple	3
The Elms	5
Other Maples	5
Tamarack	5
The Pines	7
Balsam Fir	7
Basswood	9
The Spruces	9
The Aspens	9
The Cedars	10

*Ref. 14

Using the nomograph method of sizing a wood heater, a consumer purchasing 3637 litres (800 gallons) of No. 2 fuel oil per year, with a furnace rating of 95 million Joules (90,000 BTU), who intends to use sugar maple and who wants to supply virtually all of his heat with wood, needs a firebox volume of four cubic feet. If the same consumer wishes to supply only half his heating needs with wood – using a wood-heating appliance with a capacity of 47 million Joules (45,000 BTU's per hour) – the firebox volume should be only two cubic feet.

Remember, it is very difficult to size a wood-heating appliance. It is best to discuss heating requirements with a knowledgeable dealer. If you have any doubts about size, choose a unit which is smaller rather than too large because a smaller appliance will tend to heat more efficiently and safely. As a general rule, buy the minimum size for your heating requirements.

Location of the Wood-Heating Appliance

Furnaces, of course, are installed in the basement, but the location of wood stoves is optional. If possible, locate a wood stove close to the centre of the house to facilitate even heat distribution throughout the main living area.

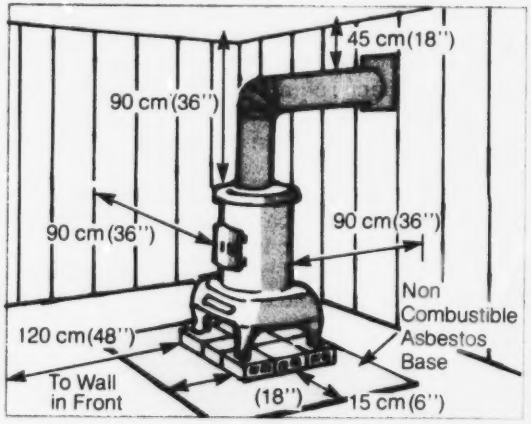
Heat Distribution Systems

All central heating units (both conventional and wood furnaces) include a heat distribution system to spread warm air throughout the house. Forced air ductwork or radiators are most commonly used.

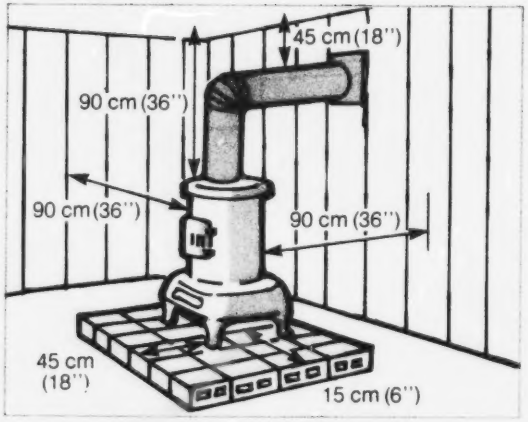
Heat distribution systems are not normally used with localized heating devices such as wood stoves, but if you want a wood stove to heat more than one room, a heat distribution system can be useful.

You can also install a wood stove in the basement. This results in better natural heat distribution (warm air rises), the stove does not take up valuable living space, and the messy operations of loading and cleaning are confined to the basement. If you choose the basement, be certain it is well insulated and install vents to allow the warm air to circulate throughout the house.

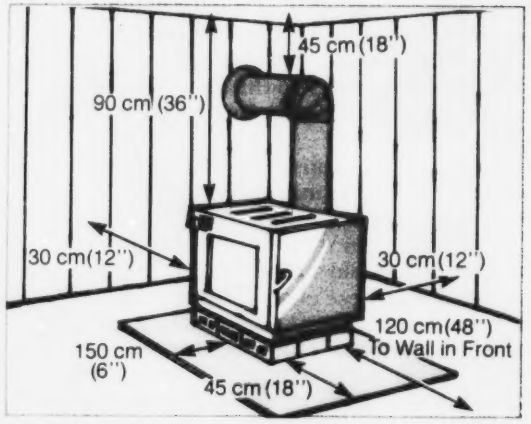
Figure 22: Clearances and Floor Protection for Stoves



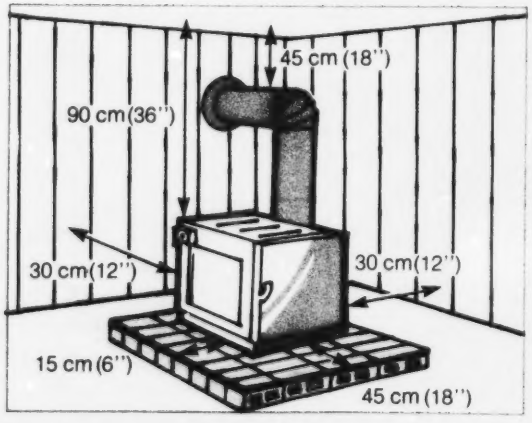
Clearances required for a radiant stove and dimensions required for a non-combustible base.



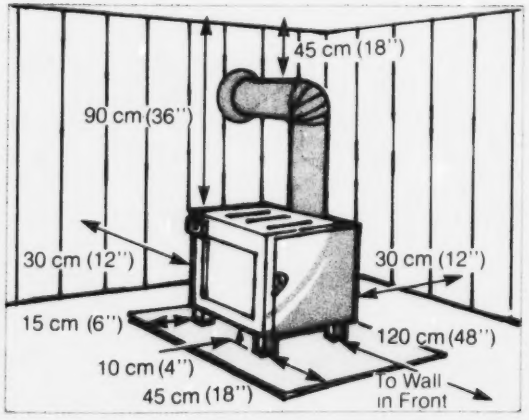
The hollow masonry block base can be extended so that there is no need to provide an additional non-combustible base.



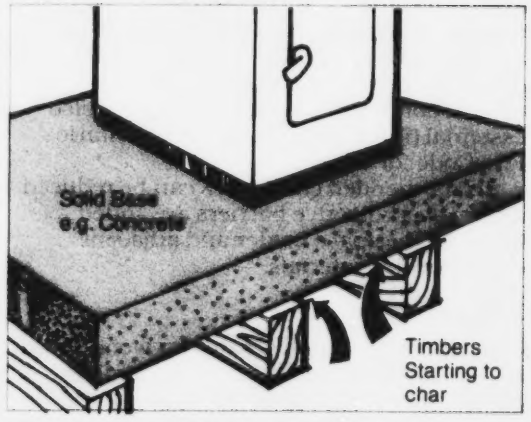
Clearances required for a circulating stove, and the dimensions required for a non-combustible base.



If the hollow masonry block base is extended, there is still the need to provide an additional non-combustible base of sheet metal and asbestos.



Non- combustible base under a circulating stove with freestanding legs of 100 mm (4") or more.



Dangerous base under a stove. Heat will be conducted through the solid base and can set fire to the timbers below.

Installing Your New System

The proper installation of your wood-heating system is essential for safe and efficient operation. The various components must be installed according to the specifications of the Ontario Fire Code[1] and the Ontario Building Code.

For safety reasons, it is critical to observe the Fire Code's minimum clearance standards (ie. the minimum distances between the components of the heating unit and combustible surfaces). On certified[2] appliances, these clearances are displayed on the name plate of the appliance. If none are shown, follow the code standards. *Unless you are already familiar with stove and/or wood furnace installation, hire a professional contractor to do the job.*

Wood Stoves

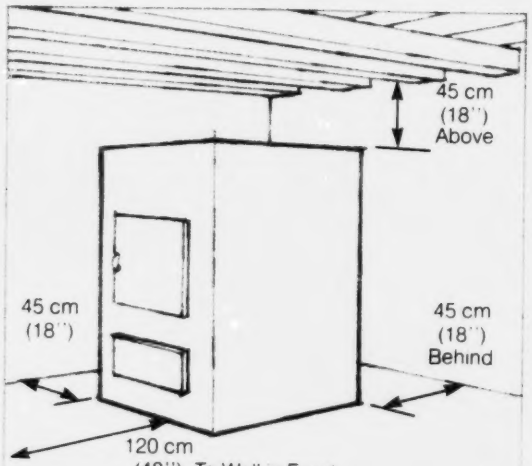
Wood stoves heat by radiation, conduction and convection. The essential criterion for the safe installation of a wood stove is to avoid over-heating of nearby or connecting combustible materials by radiation or conduction. Proper floor protection is also essential (Figure 22). Consult the Ontario Fire Code for details.

Recommended clearances can be reduced if suitable protective barriers are added between the space heater and adjacent combustible materials.

Furnaces

Clearances are much greater for wood-burning furnaces than they are for oil, gas or electric furnaces. Figure 23 shows clearances required for a wood-burning furnace and Figure 24 shows clearances for the plenum[3] and supply ducts. Again, reference should be made to the Ontario Fire Code for details.

Figure 23: Furnace Clearances



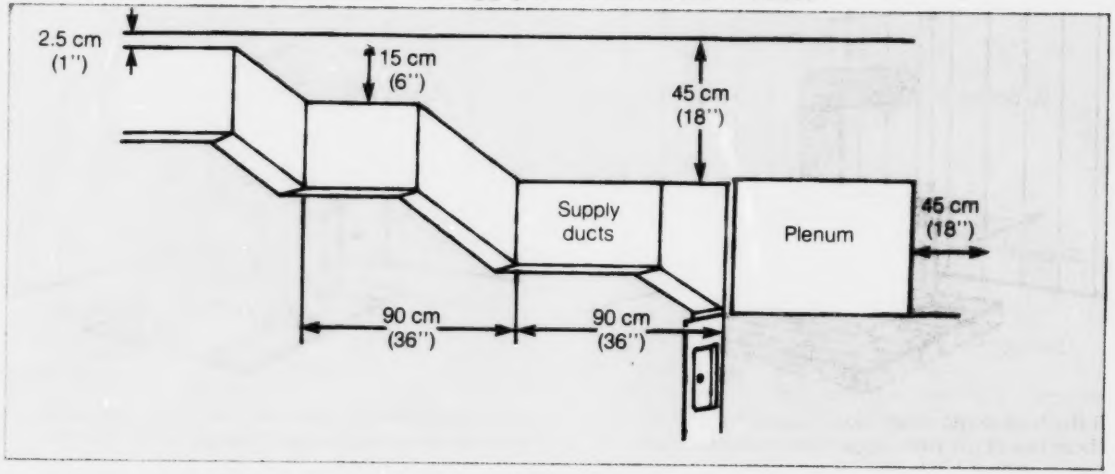
To allow for adequate air circulation, be sure to install a furnace in a room with dimensions considerably greater than the minimum space requirements. As in the case of wood stoves, the clearance distances can be reduced if certain protective materials are used[4].

The clearance distances required for the plenum and air duct can also be reduced if protective barriers are installed.

Always use a *metal return air duct* with a wood furnace to avoid over-heating and a possible house fire.

1. *The Ontario Fire Code references CSA B 365 "M" Installation Code for Solid Fuel Burning Equipment.*
2. *See Glossary.*
3. *See Glossary.*
4. *Ref. 16.*

Figure 24: Clearances for Plenum and Supply Ducts on a Wood Furnace

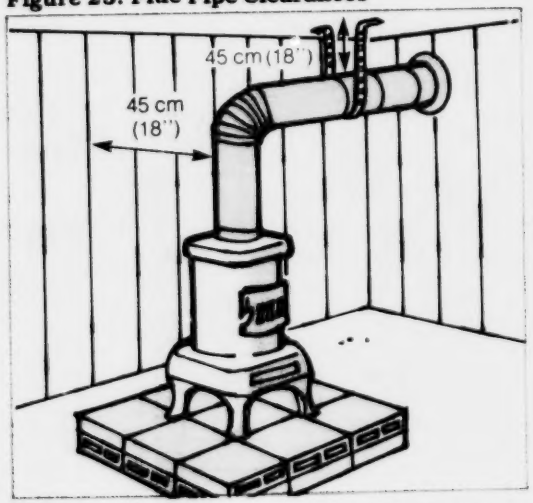


Flue Pipes

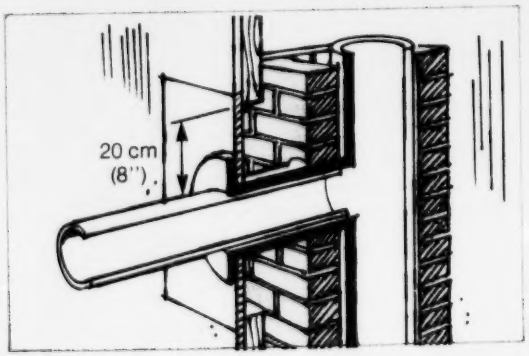
Flue pipes (also known as stove pipes in the case of wood stoves) carry combustion gases away from the wood-heating appliance. To avoid creosote buildup, make sure the pipes are as straight and as short as possible. The diameter of the flue pipes should always be the same or slightly larger than the flue collar (or outlet) of the stove or furnace.

The horizontal length of a flue pipe must not exceed 3 metres (10 feet). Flue pipes should never have more than two 90° elbows and should not penetrate combustible partitions. If they do, you must take special precautions to avoid a fire hazard. Refer to Figure 25 for the required clearances for flue pipes. If more than one flue enters the chimney, the pipe from a wood-burning appliance must always be the lowest.

Figure 25: Flue Pipe Clearances



Note that the flue pipe is independently supported by a hanger.



A metal thimble or masonry flue ring is used when a flue pipe penetrates a chimney. The thimble or flue ring should not penetrate beyond the inner surface of the chimney.

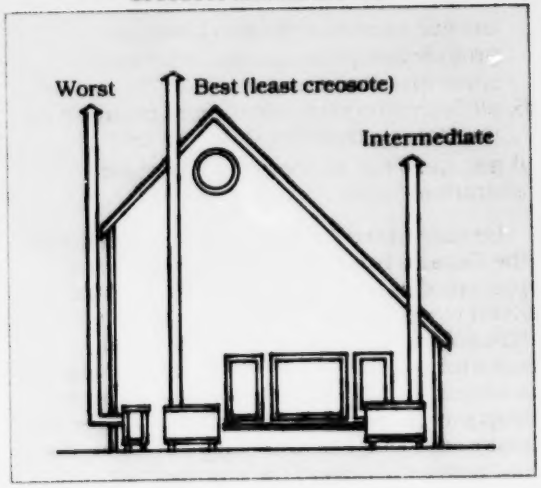
Chimneys

Faulty chimney installations cause many fires. Proper assembly, adequate clearance and use of the appropriate materials are essential for safe installation.

Factory-built insulated chimneys are most often used for new stove installations because they are less expensive than masonry chimneys and comparatively easy to install. Each certified factory-built chimney comes with a manufacturer's installation manual.

To minimize creosote formation, a chimney should pass through the interior of your house (Figure 26).

Figure 26: The Effect of Chimney Location on Creosote Accumulation



Masonry chimneys should be installed professionally by a mason and must be built according to standards set out in the Ontario Building Code[5] (Figure 27).

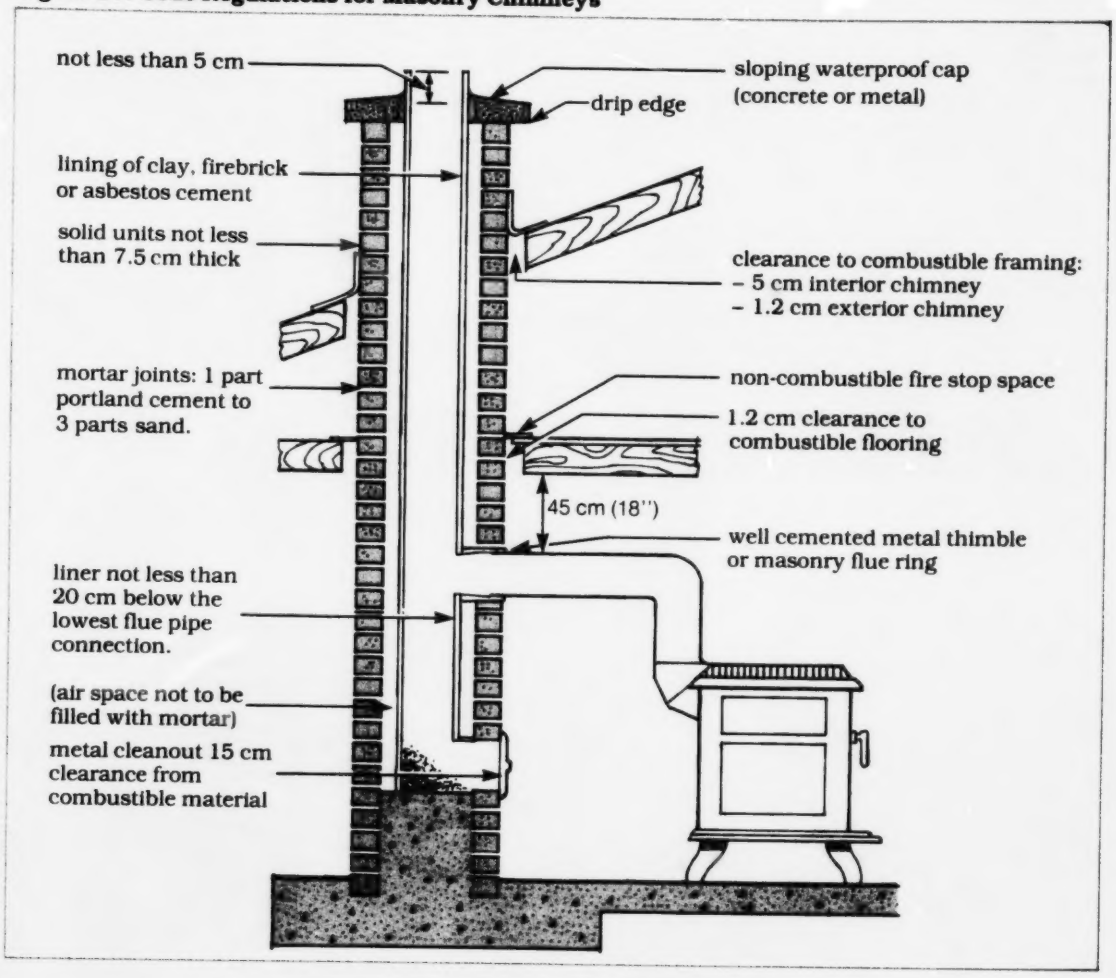
If you want to use a masonry chimney which is not currently in use, check with a professional mason or a chimney sweep to see that it meets the following conditions:

1. it is in good repair;
2. it has a fireclay liner which is at least 1.6 centimetres (5/8") thick;
3. the chimney opening in the room (thimble) and the inside flue diameter are the same size as or larger than the diameter of the stove's flue connection (stovepipe);
4. it is equipped with a metal thimble or masonry flue ring;
5. the metal or masonry thimble leading into the flue meet the Ontario Code and provide adequate clearance for wood stove installations; and,
6. all flue connection clearances required by the Ontario Building Code are met.

If not, have the necessary repairs and alterations made.

Be sure that *chimney height* conforms to the Ontario Building Code (Figure 28) to prevent smoke from blowing back down. Even when code standards are met, however, adverse wind conditions can sometimes force smoke down a chimney. In addition to keeping rain out, a rain cap can help minimize these wind effects (Figure 29). Make sure that the rain cap you choose does not restrict access to the chimney for sweeping.

Figure 27: Code Regulations for Masonry Chimneys


not less than 5 cm
sloping waterproof cap (concrete or metal)
drip edge
lining of clay, firebrick or asbestos cement
solid units not less than 7.5 cm thick
clearance to combustible framing:
– 5 cm interior chimney
– 1.2 cm exterior chimney
mortar joints: 1 part portland cement to 3 parts sand.
non-combustible fire stop space
1.2 cm clearance to combustible flooring
45 cm (18")
well cemented metal thimble or masonry flue ring
liner not less than 20 cm below the lowest flue pipe connection.
(air space not to be filled with mortar)
metal cleanout 15 cm clearance from combustible material

5. *Subsection 9.21.6 Ontario Building Code.*

Figure 28: Minimum Chimney Termination Elevations

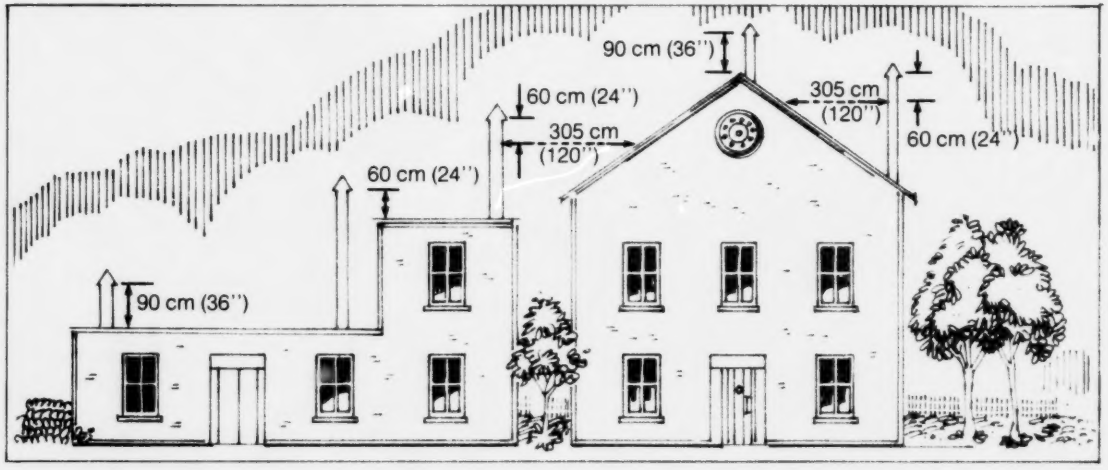
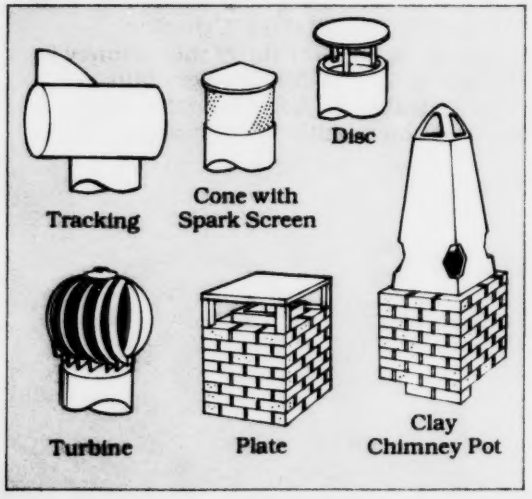


Figure 29: Rain Caps



Fireplace Inserts

Some fireplaces inserts fit partially inside the fireplace, and some fit against the face of the fireplace.

When installing an insert, seal off the space between the flue pipe and the existing chimney with a metal plate (Figure 13A). The relevant safety standard for fireplace insert installation is ULC S628 – Fireplace Insert Standard.

Provincial and Local Building Codes

Once you have decided to purchase a wood stove, check with your local municipal office to find out what the regulations are in your area. The municipal building department may ask for a building permit for the installation of a wood stove, if you also need to install a new chimney.

Be prepared to provide plans and construction details of your house to determine fire safety aspects.

Do-it-yourself Installation

Unless you have a great deal of experience, hire professionals to do the job.

If you do install your own system, make sure you follow the Ontario Fire Code and Ontario Building Code guidelines. Be *extremely* careful. In addition, consult a good handbook on the subject[6]. *If in doubt, call a local fire prevention officer.*

Installation by Contractor

Get several bids on the job (unless the purchase price of your stove includes installation). If you need a mason to do custom hearth work, he will probably give separate bids for hearth and chimney installations.

For your protection, make sure the agreement made with a contractor is spelled out in a written contract and includes a complete list of materials and services, a completion date, a guarantee on work and follow-up services, and a payment schedule.

Once the stove is connected to the chimney and the installation is complete, check the entire chimney and chimney connection, inch by inch. Make sure all joints and other components are fastened securely. Then, light a small smoky fire (using damp leaves or newspapers), and check the chimney for smoke leaks. Make any repairs necessary. Your stove is now ready for use.

6. *Ref. 15, 16, 17 and 18. Also refer to the CSA Installation Code for Solid-fuel Burning Appliances and Equipment – CSA B365 - M1982*

Chapter 6: Operation and Maintenance

Although the operation of a wood stove or a wood furnace can be safe and convenient, never forget that improper operation or maintenance is hazardous.

Tips For Safe Operation [1]

1. burn only well-seasoned wood;
2. never use flammable liquid to start or encourage the fire;
3. keep combustibles at least one metre (three feet) away from the stove;
4. exercise extreme caution each time the firebox door is open because embers, which may still be present, can spark;
5. never burn trash in the stove.

Stove and Flue Maintenance

A properly maintained wood stove should last for many years. Stoves generally require little maintenance. If your stove is used regularly, inspect it at least once annually.

Firebox: Check the grates and burn plates for burnout. These parts will eventually oxidize and will need replacement. If the firebox does not have a grate, make sure it is adequately protected by sand or ashes.

Doors: The gaskets which seal the doors on most airtight stoves should be replaced every few years.

Seams: Carefully check iron stoves with seams sealed by furnace cement, since the cement will dry out and become brittle. Furnace cement should be freshly applied as needed, and is available from most dealers.

Chimney Maintenance

Wood smoke contains three basic elements – small tar droplets, combustible vapours, and soot. When condensed, they create a combustible deposit known as creosote.

Creosote is one of the stove owner's biggest problems. If allowed to build up inside a chimney, it can create a serious fire hazard. Creosote must be removed manually. Chemicals loosen but do not eliminate deposits.

Airtight stoves tend to generate more creosote than the non-airtight designs. However, if an airtight stove with a good secondary air system is regularly fired near capacity, creosote accumulation will be kept to a minimum.

Creosote builds up most heavily in the coolest portions of the flue pipe and chimney (Figure 30). Condensation of woodsmoke, which forms creosote, can occur at temperatures ranging from about 149°C to 316°C (300°F to 600°F). If the flue temperature near the top of the chimney is kept above 149°C (300°F), very little creosote will form. A flue pipe thermometer can help you monitor flue temperature.

1. Ref. 18, 19

Figure 30: Typical Conditions and Locations for Creosote Accumulation

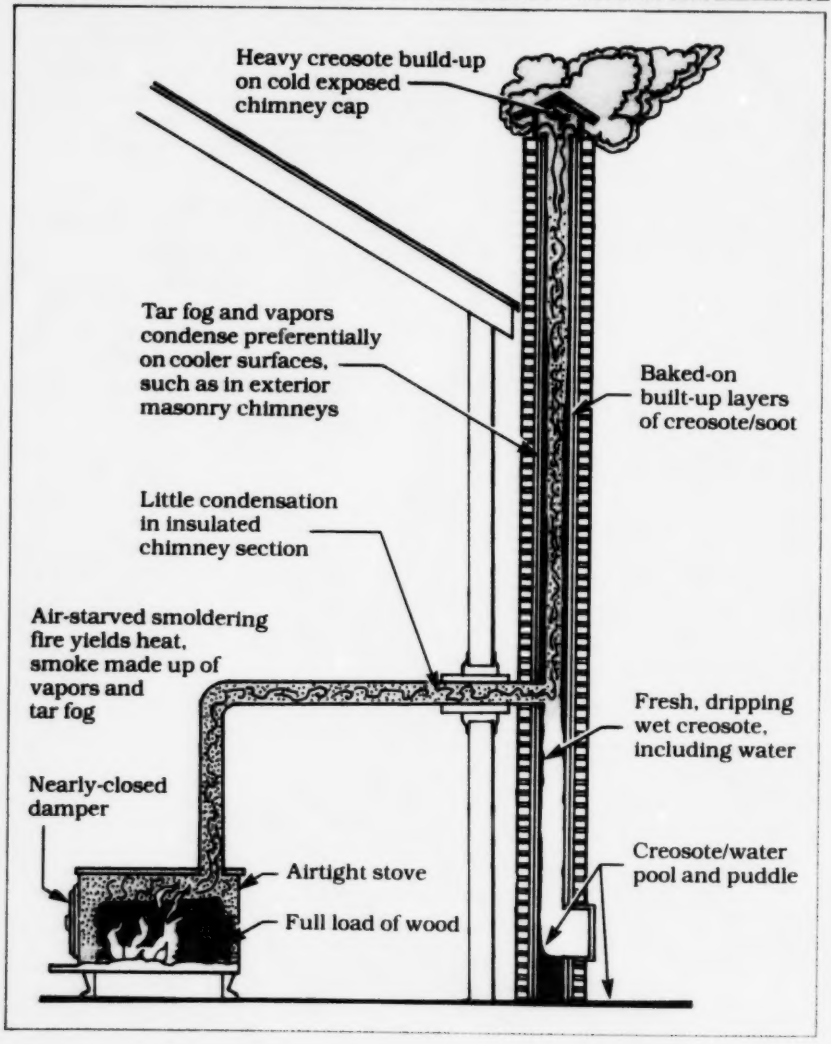
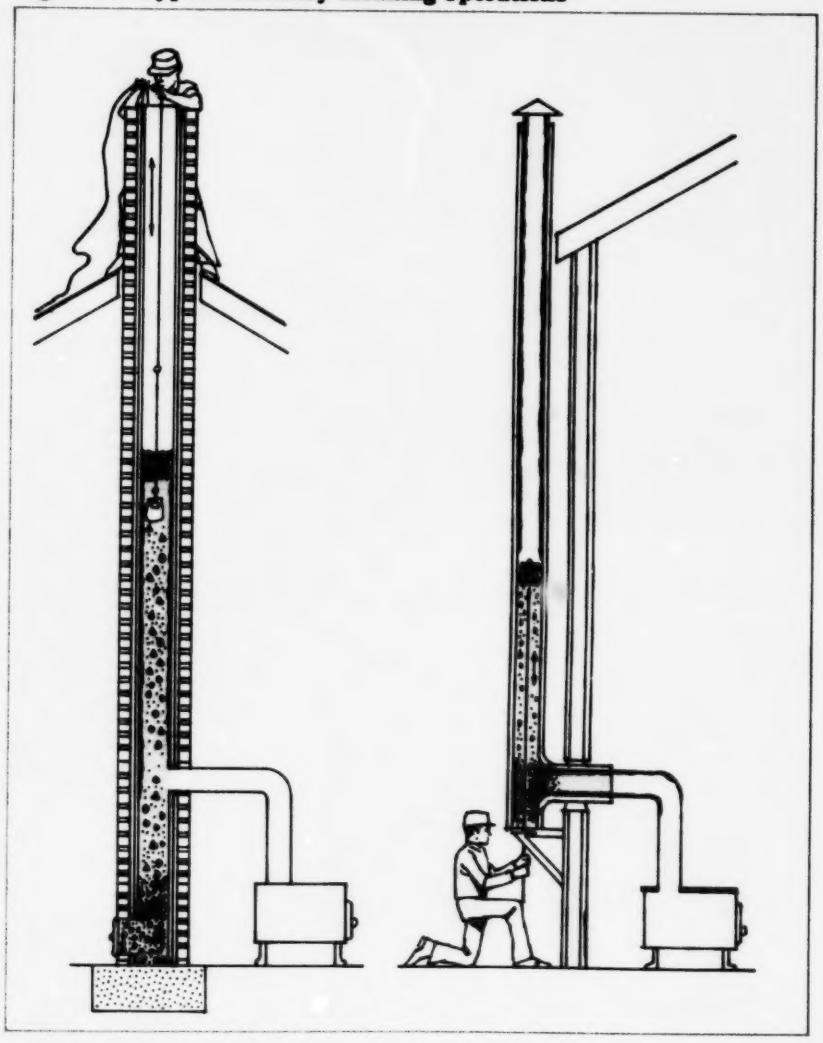

Heavy creosote build-up on cold exposed chimney cap
Tar fog and vapors condense preferentially on cooler surfaces, such as in exterior masonry chimneys
Baked-on built-up layers of creosote/soot
Little condensation in insulated chimney section
Air-starved smoldering fire yields heat, smoke made up of vapors and tar fog
Fresh, dripping wet creosote, including water
Nearly-closed damper
Airtight stove
Full load of wood
Creosote/water pool and puddle

Figure 31: Typical Chimney Cleaning Operations



Cleaning the Chimney

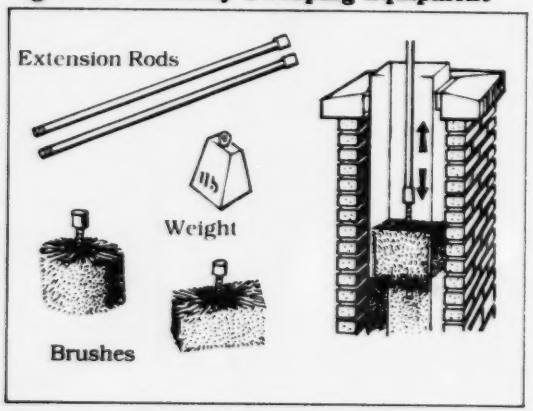
How often your chimney needs to be cleaned depends upon how often you use it, how you operate your wood-burning appliance (hot fires produce less creosote) and on the type of wood you burn. All chimneys should be cleaned a minimum of once a year. Most chimneys should be cleaned twice a year.

You can clean your own chimney unless it is exceptionally long or your roof is steeply pitched. Otherwise, hire a professional chimney sweep. (Figure 31).

If you decide to clean your own chimney, use professional equipment (Figure 32). A wire brush is essential – never use chains, bags of rocks or other heavy implements.

Lightweight fiberglass rod sections that screw together can be used in place of a rope and weight. This equipment can be used to clean the chimney from below, although you can do a better job by cleaning from above.

Figure 32: Chimney Sweeping Equipment



Chimney Fires

Chimney fires are damaging to both masonry and metal chimneys, and the sparks generated can start a house fire. A serious fire is indicated by a loud roar, heavy suction of air and a vibration. In case of a chimney fire, take the following steps:

1. alert everyone in the house;
2. close all wood-burning appliance doors and air intake draft controls; and,
3. call the local fire department.

Smoke Alarms and Fire Extinguishers

Always have both smoke detectors and fire extinguishers on hand. A good smoke detector and a good fire extinguisher (with a rating of at least 2A 10 BC) are well worth the cost in peace of mind and are indispensable in an emergency.

Two kinds of smoke detectors are available: the *ionization detector*, which is sensitive to the invisible products of combustion and the *photoelectric detector* which is sensitive to smoke. Install both kinds to ensure an early warning for smoldering fires as well as for hot, flaming fires.

Follow the manufacturer's instructions for the installation and use of all smoke detectors and fire extinguishers.

Insurance

It is important to insure your house against fire damage. At present, some insurance companies will not insure a home heated with wood; some charge higher than normal premiums, while others will accept a conversion to wood heat with no premium increase.

According to statistics compiled by the Ontario Fire Marshal's Office, the number of fires attributed to wood-fired appliances in single family dwellings doubled from 1976 to 1980.

Check out the situation in your area *before* you buy a wood stove or furnace. Additional yearly premiums for wood heat could be $100 or more.

Chapter 7: The Future of Wood Heating in Ontario

After decades of relative obscurity, wood is rapidly becoming a popular home heating fuel in Ontario. Recent advances in the design of wood heating systems have made the use of this ageless fuel increasingly convenient, efficient and safe.

Although it is difficult to provide a simple answer to the question – "will heating with wood save me money and how much?" – the cost of the alternatives is expected to escalate in the years to come. As this occurs, heating with wood will become more and more attractive.

Fuelwood for Residential Heating

Ontario depends on other Canadian provinces, as well as foreign nations, to fill about 75 per cent of its current energy requirements. This makes Ontario vulnerable to out-of-province pricing policies and to energy supply problems.

In an effort to secure our energy future, the Ontario government is encouraging energy conservation and oil substitution as well as intensified development of energy sources native to the province. As part of this overall policy, the *Energy from Waste Program*[1] was introduced in 1980. One of the program's objectives is to increase the contribution of wood to Ontario's future energy needs.

In 1980, wood contributed approximately 14.7 PJ (2.4 million Barrels of Oil Equivalent – BOE) to Ontario's residential sector[2] or about 3 per cent of the total residential energy consumed. Wood provided the main source of heat for about 90,000 Ontario homes. The Ontario government plans to actively support the adoption of wood heating to increase this contribution to an estimated 36.7 PJ (6 million BOE, or 8 per cent) by 1995. This means tripling of wood energy use in a 15-year period – a formidable challenge, but one which the Ministry of Energy believes can be met.

An increase in wood's contribution to residential heating could yield several important benefits including:

- increased employment (wood is more labour-intensive than many of the conventional energy industries);
- improvements in forest resources management (including more efficient use of underutilized biomass, and the stimulation of fast-growing tree plantations which are harvested every two to five years); and,
- improvement of Ontario's balance of payments.

1. Ref. 20
2. Ref. 2

What We're Doing to Help

The Government of Ontario is committed to its role as a catalyst in the wood energy field to ensure:

1. forest resources are carefully managed to guarantee a steady, reliable source of supply;
2. a reliable fuelwood distribution and marketing system is developed;
3. convenient heating systems (as convenient and as safe as conventional systems) are designed and made widely available;
4. standardized performance criteria are established for wood-burning appliances;
5. appropriate regulations, standards, and codes for safety and performance of wood-burning appliances are drawn up and enforced;
6. the responsibility and authority for inspection is assigned, and the appropriate level of funding for training inspectors and carrying out inspections is in place; and,
7. environmental impacts associated with wood burning are minimized.

As a fuel, wood holds a great deal of promise for the people of Ontario. It can regain at least some of its former prominence as a source of residential heat. A number of innovations in wood heating technology are currently under development. The future of wood heat – a future that relies upon the support of both the government and the citizens of Ontario – is an exciting one.

For further information on the topics mentioned in this publication, contact the following government offices.

Wood Procurement & Woodlot Management

Ontario Ministry of Natural Resources – District Offices throughout Ontario

Ontario Government Bookstore
880 Bay Street
Toronto, Ontario
M7A 1N8
965-6015 (Toronto)
1-800-268-7540 (toll free)

Heating with Wood

Ontario Ministry of Energy
Alternative & Renewable Energy Group
(Forest Resources)
56 Wellesley St. W.
Toronto, Ontario
M7A 2B7
Inquiries (416) 965-3246

COSP Grant

Energy, Mines and Resources Canada
2242 Lakeshore Blvd. West
Toronto, Ontario
M8V 1A5
252-5866 (Toronto)
1-800-268-2207 (toll free)

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11. *The Off-Oil Decision: Costs and Benefits*, Ontario Ministry of Energy, 1981.
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Glossary

Air Inlet Adjustable openings in a stove that provide control over the amount of air entering the firebox, and thus control over the rate of combustion.

Airtight Stove A type of stove in which virtually all of the combustion air enters the firebox through air inlets.

Baffle Plate A metal barrier extending into the firebox which delays the exit of combustion gases and prevents flames from entering the stovepipe.

Biomass Renewable organic matter.

BTU A British Thermal Unit is a basic heat measurement equivalent to the amount of heat needed to raise 1 pound of water 1°F.

Boiler A central heating appliance that supplies, under pressure, hot water or steam for space heating.

Capital Cost Amount of money required for equipment and installation of equipment.

Certified As by Underwriters Laboratories of Canada or Canadian Standards Association, indicating that the equipment meets nationally recognized safety standards.

Chimney Capacity Maximum quantity of flue gas which can be safely vented, often expressed in B.T.U.'s per hour capacity of the wood heating appliance used.

Chimney Fire Combustion of creosote/soot deposits inside a chimney or stovepipe.

Chimney Liner A round or rectangular sleeve usually made of high-temperature fireclay.

Circulator Stove A wood stove with an outer metal jacket surrounding the firebox. Air circulates through the air space surrounding the stove by means of convection.

Combination A central heating appliance that burns two fuels (wood-oil, wood-gas, wood-electricity).

Combustible Any material which will ignite when placed near or against a hot surface or when subjected to a flame. Refer to the National Building Code for a list of non-combustible materials and safety clearances for wood burning appliances.

Combustion A chemical process in which energy, (in the form of heat), and gases are released from biomass.

Combustion Gases Frequently flammable gases produced by burning wood. These gases will ignite and burn at temperatures of approximately 1100°F/600°C.

Conduction The flow of heat from a warmer to a cooler area.

Convection The transfer of heat through gas (including air) or liquids. When the liquid or gas is heated, it rises and is immediately displaced by cooler liquid or gas.

Cord A full cord is a quantity of wood having a volume of $3.6m^3$ (128 sq. ft.) and the measurements 1.2 m x 1.2 m x 2.4 m (4' x 4' x 8').

Creosote A tarry, black, flammable deposit caused by wood smoke vapours which condense on the inside of a chimney or stovepipe. A buildup of creosote creates a fire hazard.

Damper An adjustable metal device which regulates the flow of air or smoke in a stovepipe or chimney.

Draft Airflow through a wood burning appliance or chimney when the fire is burning.

Efficiency As applied to a wood burning appliance, it is the percentage of the total energy available in the fuelwood that becomes useful heat.

Excess Air Air passing into the firebox which, as it is not needed by the fire, is expelled through the chimney.

Face Cord A quantity of wood 1.2 metres (4 ft.) high by 2.4 metres (8 ft.) long, and less than 1.2 metres (4 ft.) wide.

Firebox Also known as the combustion chamber, it is the compartment in which combustion takes place.

Firebrick A brick lining in a firebox. Firebrick is capable of withstanding high temperatures.

Flue An enclosed passageway for conveying flue gases.

Flue Gases Gases produced from burning wood.

Heat Detector A sensing device which initiates a warning signal when exposed to abnormally high air temperature or an abnormal rate of heat rise.

Heat Exchanger A section of a stove (usually made of metal) designed for the transfer of heat from the combustion gases to the surrounding air or water.

Heat Pump An electrically operated device that, in the winter, extracts heat from the outside air and moves it inside.

Heating Appliance A device that produces heat from fuel. The term includes all components, wiring and piping of the device.

Joule The unit of energy or work in the meter-kilogram-second system of units (SI), equal to the work done by a force of magnitude of 1 newton when the point at which the force is applied is displaced 1 metre in the direction of the force. Symbolized J. Also known as newton-metre of energy. For conversion of Joules to BTU's see Appendix III.

Moisture Content The percentage of fuelwood weight that is moisture. Freshly cut "green wood" usually has a moisture content of 50 per cent while air dried "seasoned" wood has a 20 per cent moisture content.

Payback Period The time it takes for savings in the operational costs of a device to equal the initial capital investment.

Plenum A chamber connecting the furnace and the air duct system.

Radiant Stove A wood-burning appliance that heats mainly by radiation.

Radiation Transmission of heat in the form of infrared rays.

Seasoned Wood Air-dried wood with a moisture content of not more than 20 per cent.

Secondary Air Secondary air supply admitted into the firebox to ignite unburned flue gases in the secondary combustion zone.

Zero-clearance Heaters Wood heaters designed to be placed directly against combustible surfaces, with no protective barriers required.

Appendices

Appendix I

Calculation of Estimated Savings

1. (When using *fuelwood* to supplement or displace *natural gas**)

A Natural gas consumed in past year _____ (000 cubic metres)
B Expected price of natural gas. $_____
C Expected annual natural gas consumption if wood burner is installed. _____ (000 cubic metres)
D Expected reduction in natural gas consumption (A - C) _____ (000 cubic metres)
E Expected reduction in natural gas costs (D x B) $_____
F Expected price of good quality hardwood delivered (per cord) $_____
G Amount of wood required _____ cords
H Expected cost of wood fuel (G x F) $_____
I Expected savings due to wood burner (E -H). $_____
J Expected cost of wood burning installation $_____
K Payback period (J ÷ I) _____ years

*At time of publication combination wood-gas furnaces are illegal in Ontario (see page 17).

2. (When using *fuelwood* to supplement or displace *electricity*)

A Total electrical consumption during the past year (kWh). _____kWh
B Estimate of electrical consumption for household heating in past year.* _____kWh
C Portion of home heating requirements you expect to supply with wood (fraction). _____
D Expected reduction in electrical consumption (C x B). _____
E Assuming base charges must be covered, and you will use normal amount of household electricity, what is incremental price of residential electricity? _____$/kWh
F Expected reduction in electrical costs (D x E) $_____
G Expected price of good quality hardwood delivered (per cord) $_____
H Amount of wood required _____ cord
I Cost of wood (H x G) $_____
J Expected savings due to wood burning (F - I) $_____
K Expected cost of wood burning installation $_____
L Payback period (K ÷ J) _____ years

*Typically about 72% of total electrical consumption in an all-electric house.

Appendix II

Some Residential Stove Manufacturers*

Anga – Varme Stoker
Thunder Bay
(807) 623-0501

Arcson Stove Works Ltd.
London
(519) 453-7230

Robert Bell Industries Ltd.
Seaforth
(705) 527-0600

Canadian Home Fireplaces
Scarborough
(416) 292-4888

Canadian Metcraft Industries
Waterloo
(519) 884-9400

Carmour Manufacturing Ltd.
London
(519) 453-8160

Cemi Products
Hamilton
(416) 561-9343

Cera Heat Industries
Port Robinson
(416) 384-9521

Certified Steel Corp.
Mississauga
(416) 678-0011

Corbron Foundries Ltd.
Cornwall
(613) 938-9221

Crafted Wood Stoves
Barrie
(705) 737-0322

Duo-Matic – Olson
Tilbury
(416) 682-2062

EBI Industries Inc.
Cambridge
(519) 622-1410

Elmira Stove Works
Elmira
(519) 669-3367

Environ
Downsview
(416) 745-0144

Findley Comfort Systems Ltd.
Kitchener
(519) 893-6531

Harbour Mfg. Ltd.
Fort Erie
(416) 871-4010

G.A. Harding Ltd.
Markham
(416) 495-1531

Heritage Stove Co. Ltd.
Collingwood
(705) 445-5650

Hevac Mfg. Ltd.
Mississauga
(416) 275-7144

Hunter Enterprises Orillia, Limited
Orillia
(705) 325-6111

Inter-City Mfg.
St. Catharines
(416) 682-8621

Jetmaster Canada Inc.
Willowdale
(416) 449-6122

Keimer – Steco
Dorchester
(519) 268-7807

Lakewood Manufacturing
Bobcaygeon
(705) 738-2393

Leaman Energy Products
Orillia
(705) 326-5355

MCS Industries
Guelph
(519) 837-3200

Mega Energy Ltd.
St. Catharines
(416) 688-1863

MHC Mfg. Ltd.
Tweed
(613) 478-3030

Mohawk Fabricators Inc.
London
(519) 453-1306

More-Heat Stoves
St. Catharines
(416) 934-5552

Newmac Mfg.
Woodstock
(519) 539-6147

O'Dette Energies of Canada Ltd.
Kingston
(519) 549-0121

Old Timer Distributing
Kitchener
(519) 744-8202

Oliver-MacLeod Ltd.
Gravenhurst
(705) 687-3447

Procam Steel Products Ltd.
Pembroke
(613) 735-1034

Selkirk-Metalbestos Wallace Murray Canada Limited
Brockville
(613) 342-6655

Solarwood Inc.
Timmins
(705) 325-4544

Timberland, Div. of Warmth & Glo Inc.
Gravenhurst
(705) 689-5433

Triumph Energy Products
Scarborough
(416) 431-0324

Wolf Steel Stoves
Barrie
(705) 737-2121

Wolfedale Engineering Ltd.
Mississauga
(416) 279-2632

Wood-En Distributors Limited
Downsview
(416) 663-5090

*Information supplied by the Canadian Wood Energy Institute. We regret any omissions. Inclusion on this list does not constitute an endorsement by the Government of Ontario of the equipment offered. It is suggested that a number of competitive quotations be obtained for any equipment.

Appendix III Conversion Table

Metric Unit		Imperial Unit
Divide the number of	**by**	**to find the number of:**
litres (L)	4.546	gallons (Imperial)
kilojoules (kJ)	1.055	BTU's
gigajoules (GJ)	1.055	million BTU's
petajoules (PJ)	1.055	10^{12} BTU's
watts (W)	0.2931	BTU's per hour
cubic metres (m^3)	0.0283	cubic feet (ft^3)
square metres (m^2)	0.0929	square feet (ft^2)
metres (m)	0.305	feet
degrees Celsius (°C)*	5/9	degrees Fahrenheit (°F)
cubic metres	3.625	1 cord (stacked)

*To convert degrees Celsius to degrees Fahrenheit: (°C x 9/5) + 32

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Notes

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